A STUDY OF HIGH ACCIDENT RATES ON CERTAIN HIGHWAYS IN INDIANA

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Joint Highway Research Project

by

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PURDUE UNIVERSITY
LAFAYETTE INDIANA

FINAL REPORT

A STUDY OF HIGH ACCIDENT RATES

ON CERTAIN HIGHWAYS IN INDIANA

TO:	K. B. Woods, Director Joint Highway Research Project	September 25, 1958
FROM:	H. L. Michael, Assistant Director Joint Highway Research Project	File: 8-5-4 Project: C36-59D

Attached is a final report, "A Study of High Accident Rates on Certain Highways in Indiana," by Mr. H. H. Blindauer. Mr. Blindauer also used this study as his thesis as part of the requirements for the Master of Science in Civil Engineering Degree. The study was conducted under the supervision of Prof. H. L. Michael.

This study located twenty-five locations where accidents are occurring in large numbers due to assignable causes. Recommendations are made for each of these twenty-five locations for improvements. It is suggested that the State Highway Department consider the suggestions made.

The report is presented for the record.

Respectfully submitted,

H. L. Michael

H. L. Michael, Secretary

HLM:acc

Attachment

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FINAL REPORT

A STUDY OF HIGH ACCIDENT RATES ON CERTAIN HIGHWAYS IN INDIANA

by

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Joint Highway Research Project
File No: 8-5-4
Project No: C36-59D

Purdue University
Lafayette, Indiana

September 25, 1958

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to all the men who made this study possible, particularly to Professor Harold L. Michael, Assistant Director of the Joint Highway Research Project; Professor I. W. Burr of the Statistics Department; Sergeant Ralph Powell, Head of the Accident Records Bureau of the Indiana State Police; and W. H. Behrens, Road Plans Engineer of the Indiana Highway Department.

Thanks are also extended to other members of the Indiana State Police and Indiana Highway Department who aided in the data collection for this study.

Lastly, the author is indebted to the Joint Highway Research Project, without whose financing and facilities this study would have been impossible.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Blindauer, Harlan Healy, M. S., Purdue University, August 1958. A Study of High Accident Rates on Certain Highways in Indiana. Major Professor: Harold L. Michael.

The purpose of this study was to investigate a number of highways in Indiana having high accident rates and to determine causes of these rates and possible correction measures. The study was confined to the location and analysis of highway elements which might contribute to the occurrence of accidents. These elements included intersections, structures, railroad crossings, horizontal and vertical curves, and private and commercial driveways. Only rural two-lane highways were analysed.

The accident rates used in this study were accidents per million vehicles and accidents per million vehicle miles. Accidents were divided into four categories: (1) accidents occurring at intersection; (2) accidents occurring at structures; (3) accidents occurring at railroad crossings; and (4) other accidents. All accidents for the two-year period, 1956 and 1957, were used.

Ten test sections with a total length of 200.7 miles were chosen in various parts of the state and divided into 207 individual subsections. The industrial quality control type of analysis was used for each of the four types of accidents. When the control charts were plotted using three standard deviations for the upper control limits,

the following results were found: (1) for accidents at intersections, 8.0% of the subsections containing intersections were out of control; (2) for accidents at structures, 8.2% of the subsections containing structures were out of control; (3) for accidents at railroad crossings, 10.0% of the subsections containing railroad crossings were out of control; and (4) for other accidents, 5.3% of all subsections were out of control. All out of control subsections were investigated further, and if assignable causes for accidents were found, recommendations were made for improvements.

The results indicated that the quality control type of accident analysis, if used properly, could substantially contribute to a reduction in automobile accidents.

A STUDY OF HIGH ACCIDENT RATES OF CERTAIN HIGHWAYS IN INDIANA

INTRODUCTION

With the advent of the automobile as a mode of transportation late in the nineteenth century, a new phenomenon, the automobile accident, appeared on the American scene. While the motor vehicle was in its early stages of development, the problem was not serious. However, as the volume of cars on the highways increased, the number of accidents increased also, and the problem began to assume greater and greater proportions. In 1955 approximately ten million accidents occurred, resulting in 36,000 deaths and costing the American economy more than four billion dollars.[1*]

Three elements contribute to automobile accidents; the driver, the vehicle, and the highway. Quite obviously, the highway engineer does not have complete control over the first two elements since driver characteristics are concerned mainly with education and enforcement, and vehicle characteristics are primarily the responsibility of the automotive industry. The highways, however, are a direct reflection on the members of the highway engineering profession, and it is the responsibility of this group to make them as safe as possible for all drivers. In light of the ever increasing number of accidents on American

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* The floating numbers refer to Bibliography.

roads, the highway engineer has many opportunities to contribute to safer highways.

The year 1956, with the passage of the Interstate Highway Act, produced a concerted effort to build safety into highways, but the 41,000 miles comprising the Interstate Highway System is only 1.2% of all roads in the United States. Even after this vast system of superhighways is built, a large percentage of the remaining highways will be below acceptable standards. Because, in all probability, there will never be enough money to reconstruct all roads to modern standards, it is up to the highway engineer to accept this situation and make existing highways as safe as possible under prevailing conditions.

However, existing highways cannot be made safer in the most efficient manner unless accident data are compiled and analysed. At present, most states keep very complete files of accident reports, but very little has been done in utilizing these reports in accident analyses of specific sections of highway. This is at least partially due to the fact that accident reports, even in the same area, are often inaccurate as to location, type of accident, and prevailing conditions at the time of the accident.

Some accident studies have been made with varying degrees of success. However, many more studies must be made before the highway engineer can attempt to understand more fully the causes of automobile accidents.

PURPOSE

The purpose of this study was to investigate a number of highways in Indiana having high accident rates and to determine causes of these rates and possible corrective measures.

PREVIOUS STUDIES

The role that highway elements play in contributing to accidents is, at the present time, relatively unknown. Many investigations have been performed in the past attempting to correlate with accident rate such factors as the number of intersections and driveways, horizontal and vertical curvature, road and shoulder width, traffic volume, capacity, structures, number of lanes, grades, and commercial and residential development along the highways.

The Michigan State Highway Department investigated a 70 mile section of U.S. 24 and found reasonably good correlation of accidents with features such as gas stations, stores, and intersections.[2]

The Bureau of Public Roads in a study of accident rates on 5,000 miles of primary highway found that traffic volume had a strong effect on accident rate, but could not find any consistent effect with other factors.[3]

The Oregon State Highway Department, in a study of 1,400 miles of two-lane highways found that accidents tended to increase when: (1) volumes increase, (2) access points increase, (3) sight distance is impaired, and (4) the cross-section is reduced.[4]

The Bureau of Public Roads, in a study of 1,000 miles of highway with varying degrees of access control, found that the more access control present, the lower the accident rate.[5] Adolph May confirmed this in an investigation performed at Purdue University.[6]

John Woo, in an accident study on a state wide level in Indiana, found good correlation of accidents with traffic volume, congestion index, lane width, and total entrances per mile, but found very little correlation with capacity, shoulder width, and horizontal alignment.[7]

The University of California at Berkeley investigated the effect of shoulder width on accident rate and found that the rate appeared to increase as shoulder width increased, except at traffic volumes below 2,000 vehicles per day, where the trend was reversed.[8]

In general, the results of investigations have been inconclusive, and, in many instances, contradictory.

PROCEDURE

In this study, all sections investigated were two-lane highways in rural areas. There were several reasons for this. Because a large majority of the highways in Indiana have only two lanes and probably will remain two-lane highways for many years to come, the greatest need for research was on this type of facility. Rural highways were selected for this first study because of the relative homogeneity of conditions affecting accidents.

Selection of Test Roads

In the selection of test roads, three criteria were utilized: (1) each of the test road sections should be of sufficient length to present several different subsection accident rates; (2) the overall accident rate on each test road section should be well above the average accident rate in Indiana; and (3) the test roads should be located throughout the state in order to present a variety of conditions.

As to the actual selection, two sources of information were used: (1) the progress report on "Correlation of Accident Rates and Roadway Factors" by John C. H. Woo presented to the Joint Highway Research Project on July 24, 1957, which lists all sections of primary state highways in Indiana having an accident rate of at least eight accidents per mile for the two year period, 1954-55[9], and (2) a map of Indiana published by several Indiana newspapers showing the ten sections of highway in Indiana having the highest traffic fatality rates in 1957. However, any sections which were reconstructed after December 31, 1955, were not considered.

From the above sources, ten rural sections were selected. They are as follows:

(1) State Road 25 - Lafayette to Delphi

(2) U.S. Highway 31 - Miami County

(3) U.S. Highway 24 - Burnetsville to Peru

(4) State Road 37 - Monroe County

(5) State Road 37 - Indianapolis to Johnson-Morgan County Line

(6) State Road 37 - Morgan County

(7) State Road 9 - Anderson to Madison-Grant County Line

(8) State Road 67 - Delaware County

(9) U.S. Highway 36 - Hendricks County

(10) State Road 67 - Morgan County

The ten test sections are shown in Figure 1. Henceforth, they will be referred to in this report by the numbers listed above.

Each section was subdivided into subsections of convenient length, usually one mile.* In general, the subsection were numbered by direction from the major town or city on the section with the terminal points of each subsection half-way between integer miles from the city limits. This was because most accident reports give the location of an accident as an integer number of miles from the city limits of the major town or city within the county in which the accident occurred.

Collection of Data-Highway Elements

Before any other data were collected, it was necessary

* See appendix for list and description of subsections.

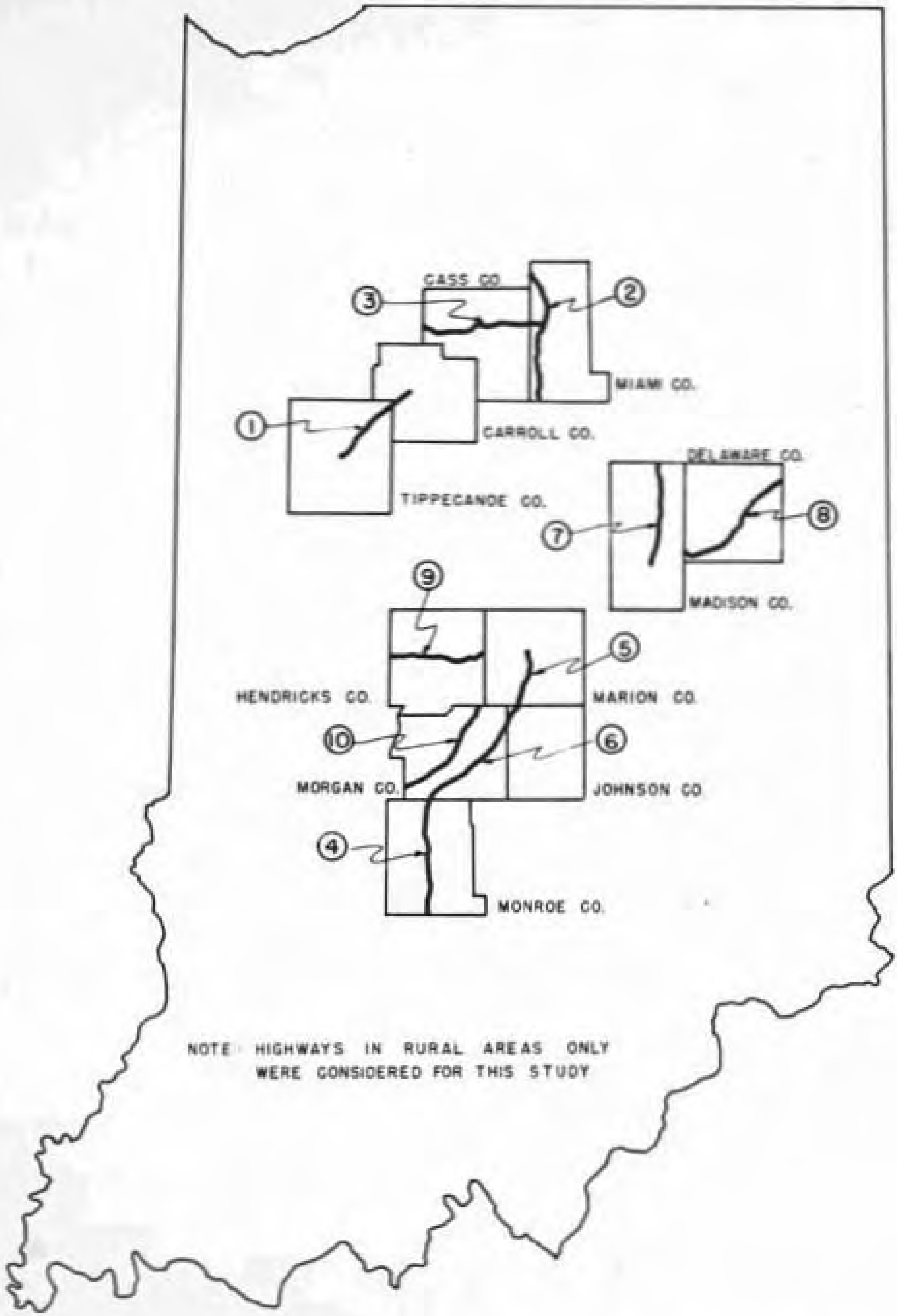

FIGURE 1 MAP SHOWING LOCATIONS OF TEST SECTIONS

to locate as accurately as possible the various highway elements such as private and commercial driveways, intersections, structures, and railroad crossings. Not only was this information used in the data analysis, but it also helped to locate many accidents quite closely since a majority of accident reports not only gave the mileage to the nearest city but also gave a distance from some feature such as an intersection or a structure in the immediate vicinity.

A Streetor-Amet Travel Time and Distance Recorder was used exclusively to locate the highway elements. This instrument, shown in Figure 2, consists of a timer, a distance wheel, and a printing mechanism and is designed to permit automatic recording of travel times and distances at different points along a highway. A roll of paper moves through the recorder, and the readings on electrically operated counters can be recorded on this paper by pressing a print button. A timer is wired to one printing counter, and the counter advances one hundred numbers per minute. A second counter is actuated by a speedometer cable connected to the cable of the test car. This counter permits recording of distance to the nearest hundreth of a mile. A third counter, which reads from 1 to 12, is actuated by a rotary solenoid which is controlled by a set of numbered keys on a control panel. This counter is used to code the data on the other two counters. The recorder is mounted on the front seat of a test car and can be operated either

Figure 2. Streeter-Amet Travel-time and Distance Recorder

by the driver or a second observer.

In this study, each type of highway element was assigned a certain code key. The test car was parked at the beginning of a test section and the distance recorder set at zero. The car was then driven along the section, and whenever a highway element was encountered, the proper code key was pressed and the distance and code key designation recorded on the paper tape. Since travel time was not a factor in this study, it was set to remain at zero. The paper tape of a portion of one of the test runs is shown in Figure 3.

Collection of Data-Accidents

After the highway features on all ten test sections were located and recorded in the proper subsections on a tally sheet, the recording of accidents was begun. When this study was initiated, it was planned that the accidents would be recorded according to the type of friction which caused each accident; i.e., intersectional, marginal, medial, or internal stream.[10] However, it was found that when this method of recording accidents was actually tried, the accident descriptions on most of the reports were very vague and inconsistent, and the data resulting from such a procedure was very doubtful as to its accuracy.

Therefore, an approach was used which gave reasonably accurate and usable results. The accidents were classified according to the highway features at which they occurred. The classifications used in this study were: (1) accidents

	CODE COLUMN	TIME (SET TO REMAIN AT ZERO)	DISTANCE TO $\frac{1}{100}$ OF MILE
CITY LIMITS	1	0 0 0 0 0	1 1 3 8
INTERSECTION	5	0 0 0 0 0	1 1 3 8
COMM. DRIVEWAY	8	0 0 0 0 0	1 1 3 7
	8	0 0 0 0 0	1 1 3 6
PRIVATE DRIVEWAY	12	0 0 0 0 0	1 1 3 [illegible]
	12	0 0 0 0 0	1 1 3 3
	5	0 0 0 0 0	1 1 2 7
	8	0 0 0 0 0	1 1 2 5
	12	0 0 0 0 0	1 1 2 4
	12	0 0 0 0 0	1 1 2 3
	8	0 0 0 0 0	1 1 2 2
	8	0 0 0 0 0	1 1 1 9
RAILROAD CROSSING	10	0 0 0 0 0	1 1 1 8
	10	0 0 0 0 0	1 1 1 7
	10	0 0 0 0 0	1 1 1 6
	8	0 0 0 0 0	1 1 1 4
	8	0 0 0 0 0	1 1 1 2
	8	0 0 0 0 0	1 1 1 1
	12	0 0 0 0 0	1 1 0 7
STRUCTURE	3	0 0 0 0 0	1 1 0 0
	8	0 0 0 0 0	1 0 9 9
	12	0 0 0 0 0	1 0 9 1
	5	0 0 0 0 0	1 0 8 8
	5	0 0 0 0 0	1 0 8 1
	12	0 0 0 0 0	1 0 7 8

FIGURE 3 SAMPLE OF HIGHWAY FEATURE DATA

occurring at intersections; (2) accidents occurring at structures; (3) accidents occurring at railroad crossings; and (4) other accidents. Structures included all major and minor bridges, but not culverts.

All accidents which occurred in the two year period from January 1, 1956, to December 31, 1957, were then recorded on tally sheets according to classification and, as accurately as possible, by subsection.

Collection of Data-Traffic Volume

Traffic volumes for the ten test sections were obtained from the 1957 Traffic Flow Map of Indiana published by the State Highway Department of Indiana.

Collection of Data-Highway Capacities

The capacities for the test sections were obtained from the road inventory sheets on file in the transportation laboratory of Purdue University. These data were computed originally for the Indiana Highway Needs Study.

Collection of Data-Horizontal and Vertical Curvature

The horizontal and vertical curvature for the test sections were obtained from construction plans on file in the road plans section of the Indiana Highway Department. The point of intersection, degree of curvature, intersection angle, and length of each horizontal curve with degree of curvature of at least three degrees were recorded. Also, the point of intersection, length, and grade on both sides of the point of intersection of each vertical curve with an algebraic difference of over one and one half percent were recorded. It was assumed that any horizontal curve with a degree of curvature of less than three degrees and any vertical curve with an algebraic difference in grade of one and one half percent or less were not critical and, therefore, would not be considered.

ANALYSIS OF DATA

Since the purpose of this study was to determine causes and possible methods for reducing accident rates on specific sections of highway, some method had to be found to highlight those subsections having accidents due to assignable causes. When this study began, it was planned to utilize correlation and regression in locating assignable causes; but, as the study progressed, another method of analysis was found which presented much better results. That method was statistical quality control.

Development of Method of Analysis

Statistical quality control has been used for many years in American industry to gauge the performance of men and machines. Control charts with appropriate control limits give a good indication of variation due to random error alone and variation due to assignable causes. Therefore, it seemed logical that if quality control could gauge the performance of machines, it might also be used to gauge the performance of highways.

The idea of using quality control in accident analyses is not entirely new. Messrs. Norden, Orlansky, and Jacobs of Dunlap and Associate in Stamford, Connecticut, investigated the possibility in 1956 and found that applying this technique to an actual highway situation gave results showing strong promise that the application of this method might contribute substantially to a reduction in automobile accidents.[11]

In specific terms, the quality-control type of accident analysis is as follows: A certain section of highway is divided into subsections, and the accidents on each subsection are compiled. The accidents are converted to some standard unit of measure and plotted on a control chart. The appropriate upper control limits are computed and also plotted, and those subsections which are out of control are investigated further for assignable causes. If this method is applied to several sections of highway, as it was in this study, it remains substantially the same with one exception; the sections are tested first to ascertain whether or not they are in control. All sections in control are tested with one standard centerline value, and any section out of control is tested separately with its own centerline value.

It is important to note that even though a very large majority of the subsections will be in control, this does not necessarily indicate that there are not present on these segments assignable causes which contribute to accidents. This is especially true for this study because only high-accident highways were considered for analysis.

When the above procedure was applied to this study, one problem immediately arose. What would be a logical standard unit of measure for the four types of accidents? For accidents occurring at intersections, structures, and railroad crossings, the answer was relatively simple. Since all of these types occurred at single points, they could be converted to an element of risk:[12]

$$\text{Element of Risk} = \frac{\text{Number of Accidents}^{*}}{\text{AADT }(365)(2)}$$

Because the subsections used in this study were generally one mile or less in length, no more than one structure, intersection, or railroad crossing usually occurred in each subsection. In the few subsections where more than one of any of these features occurred, each intersection, structure or railroad crossing was analysed separately after completion of the control charts.

An additional refinement to the element of risk for intersections and railroad crossings could be made by including in some manner the traffic volumes on cross roads for intersection analysis and the number of trains per day for railroad crossing analysis. These refinements were not incorporated in this study because of the non-availability

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* Since the various numbers of accidents were for a full year period, the Average Annual Daily Traffic (AADT) was converted to the number of vehicles in two years by the constant 365(2).

of traffic volumes on cross roads and of comprehensive information on train movements.

For the other accidents, the problem was somewhat different. Since these included accidents due to horizontal and vertical curvature, private and commercial driveways, insufficient pavement and shoulder width, congestion, and other factors, it was reasoned that, in general, they might be more or less uniformly distributed throughout each subsection. Therefore, the question of subsection length arose because, in all probability, accident occurrence on a subsection two miles in length would be greater than on a subsection one half mile long if similar conditions were present on both subsections. To account for this, it was decided to use vehicle miles travelled on the subsections rather than vehicles in the denominator of the element of risk equation:[11]

$$\text{Element of Risk} = \frac{\text{Number of Accidents}}{(\text{AADT})(\text{Length})(365)(2)}$$

With standard units of measure for accidents determined, only one problem remained, that of finding a standard expression for the control limits of the various sections and subsections. In order to find the solution, it was necessary to refer again to quality control as used in industry.

When dealing with fraction defectives, a mean and standard deviation can be computed for the binomial destribution; and, although the distribution may be quite skewed, there will be, by chance causes alone, very few points outside the band between the mean minus three standard deviations and the mean plus three standard deviations. Hence, having set such limits, the statistician has a band of normal variability for the statistical measure in question.

$$p_i = \frac{d_i}{n_i}$$

$$\bar{p} = \frac{\sum d_i}{\sum n_i}$$

$$s_i = \sqrt{\frac{\bar{p}(1-\bar{p})}{n_i}}$$

$$CL_i = \bar{p} \pm t \times s_i$$

Where p_i = the defective probability in any sample

$\bar{p}$ = the overall defective probability

d_i = the number of defectives in any sample

n_i = the number of pieces in any sample

s_i = the estimate of the standard deviation of any sample

CL_i = the control limits for p_i of any sample

t = the number of standard deviations from $\bar{p}$ to either the upper or lower control limits

In general, regardless of the skewness of the distribution, less than 0.5 percent of all individual probabilities should be outside the control limits due to chance alone when the mean plus or minus three standard deviations is used to set those limits.

When applied to this study, the above expressions could be used quite readily. In final form, they appeared as follows:

$$p_i = \frac{a_i}{n_i}$$

$$\bar{p} = \frac{\sum a_i}{\sum n_i}$$

$$s_i = \sqrt{\frac{\bar{p}}{n_i}}$$

$$CL_i = \bar{p} \pm 3s_i$$

Where p_i = the element of risk on any subsection

$\bar{p}$ = the overall element of risk on any section or series of sections

a_i = the number of accidents on any subsection

n_i = the number of vehicles or vehicle-miles on any subsection, the unit of measure depending on the type of accident being analysed

s_i = the estimate of the standard deviation of any subsection

CL_i = the control limits for p_i on any subsection

It will be noted that in the expression for s_i the term $(1-\bar{p})$ was eliminated. It was found that it very nearly approached unity and therefore could be ignored.

Analysis-General

With the method of analysis determined, the next problem was to apply it to the various types of accidents on the test sections. Before any actual analysis could be performed, it was necessary to compute the AADT on each subsection. The traffic count data were given at each side of major intersections only, so it was assumed that there was a linear variation of traffic from one intersection to another. Using this assumption, the various AADT's were plotted in graph form and the subsections superimposed on these graphs in their proper positions. The average traffic volume moving through each subsection was then read directly to the nearest 100 vehicles. When a major intersection fell within a subsection, a weighted average was obtained taking into account the relative position of the intersection within the subsection.

Analysis-Accidents at Intersections

Elements of risk on all subsections having accidents at intersections were computed. Also computed were the element of risk on each section and the overall element of risk utilizing the two year traffic volumes for those subsections having intersections.

Before making the final analysis, it was necessary to plot a control chart with appropriate upper and lower control limits for the elements of risk on the sections. As indicated on the chart shown in Figure 4, Section 5, State Road 37 from Indianapolis to the Johnson-Morgan County Line, was out of control. A new overall risk element was computed for the nine sections in control, and control charts for the subsections were plotted with appropriate upper control limits. A control chart for Section 5 was plotted separately with its own element of risk and upper control limits.

The control charts for accidents at intersections are shown in Figures 5 to 9.

Analysis-Accidents at Structures

The analysis of accidents occurring at structures was similar to that of accidents at intersections except that the two-year traffic volumes only for those subsections having structures were used. As shown in Figure 4, all sections were in control, so all the subsections were analysed with one overall element of risk.

The control charts for accidents at structures are shown in Figures 10 to 14.

Analysis-Accidents at Railroad Crossings

Due to the rarity of railroad crossings, it was decided to analyse accidents occurring at these points directly without any consideration of sections. The accidents on each subsection were converted to elements of risk, and an overall risk element was computed utilizing the two year traffic on only those subsections having railroad crossings. A control chart, shown in Figure 15, was plotted with appropriate upper control limits.

Analysis-Other Accidents

The analysis of other accidents was quite similar to that of accidents at intersections except that the vehicle miles in each subsection were used instead of traffic volumes. As shown in Figure 4, all sections were found to be in control, so all the subsections were analysed with one overall element of risk.

The control charts for other accidents are shown in Figures 16 to 20.

Results of Analysis

By visual inspection of the control charts shown in Figures 6 to 20, the following results were obtained: (1) for accidents at intersections, 15 out of 188 subsections containing intersections, or 8.0 percent, were out of control; (2) for accidents at structures, 6 out of 73 subsections containing structures, or 8.2 percent, were out of control; (3) for accidents at railroad crossings, 1 out of 10 subsections containing railroad crossings, or 10.0 percent, were out of control; and (4) for other accidents, 11 out of 207 total subsections, or 5.3 percent, were out of control. All out-of-control subsections are given by subsection number and type of accident in Table 1.

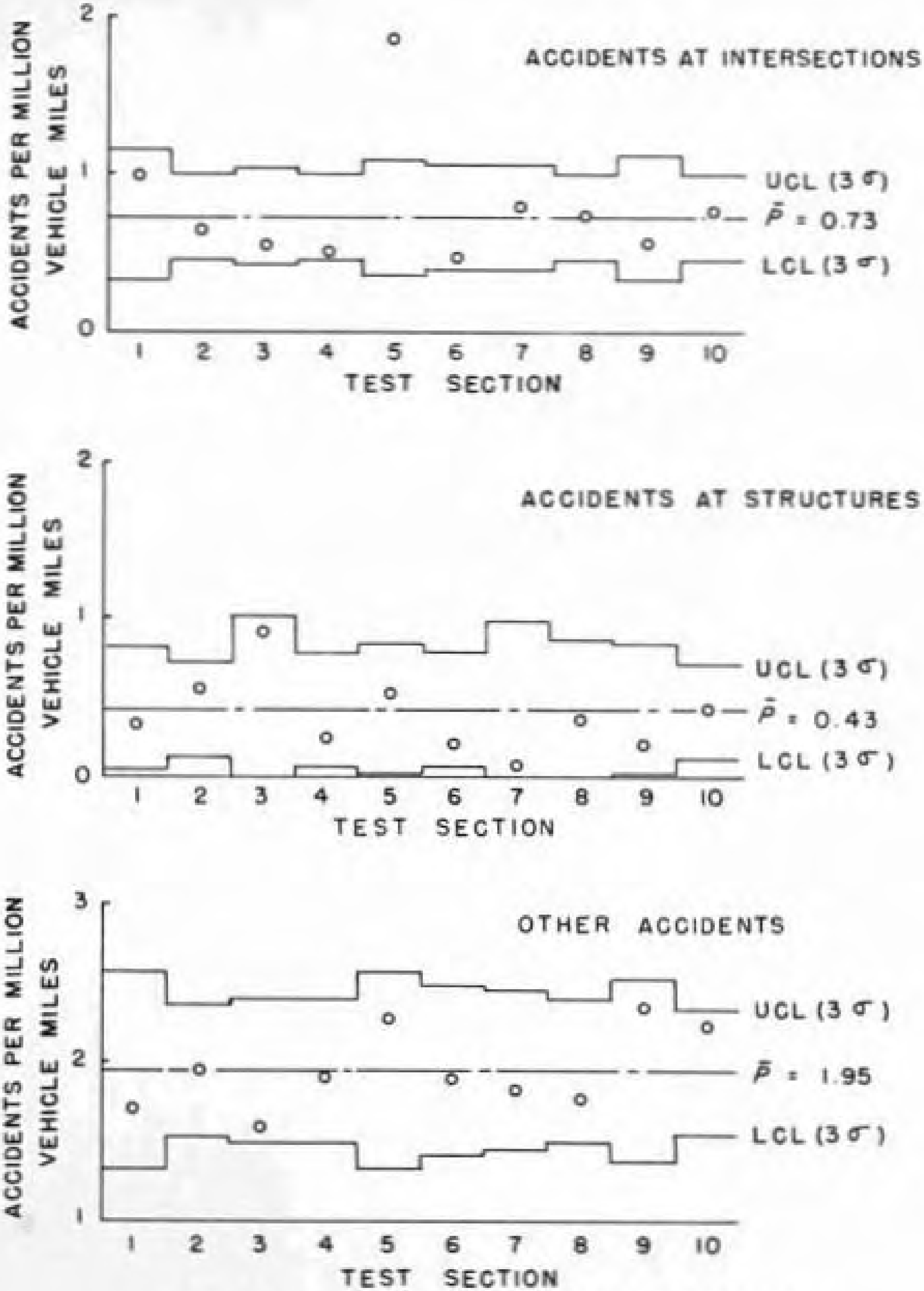
Search for Assignable Causes

After the out-of-control subsections were located by visual inspection of the control charts, it was necessary to reappraise the accidents on those subsections in an attempt to find assignable causes.

Again utilizing the accident reports for the years 1956 and 1957, collision diagrams were made for all intersections, structures, and railroad crossings within the out-of-control subsections. Also, as much as possible, those subsections which were out of control for other accidents were investigated for features which caused or contributed to accident occurrence. It was found, however, that due to the limited amount of information available on the reports for other accidents, only horizontal and vertical curvature and commercial and private driveway information could be used.

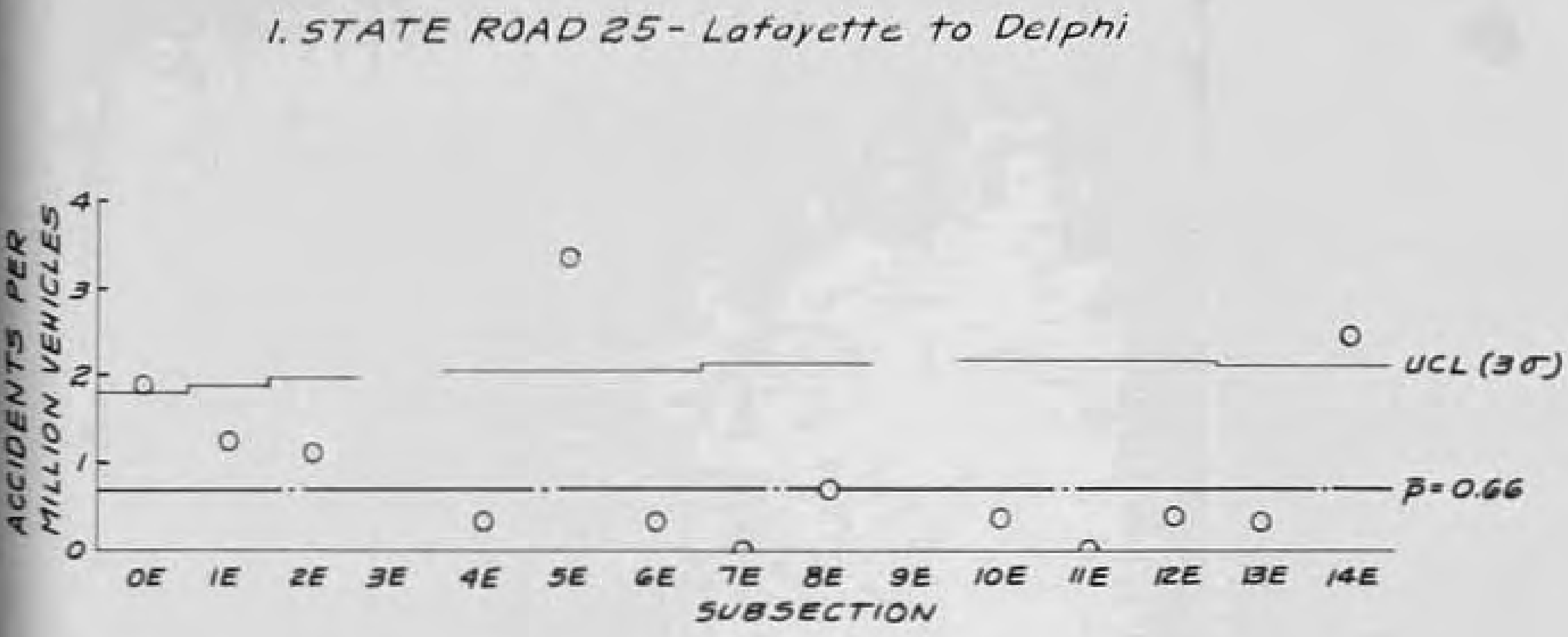
From the final accident analysis, it was possible at a number of the locations to isolate features which were caused or contributed to the occurrence of accidents. All out-of-control locations were investigated in the field to find out what conditions existed which were hazardous to motorists, and what remedial measures could be taken to reduce the accidents at those locations. The results of the analysis of each out-of-control subsection are shown in Table 2.

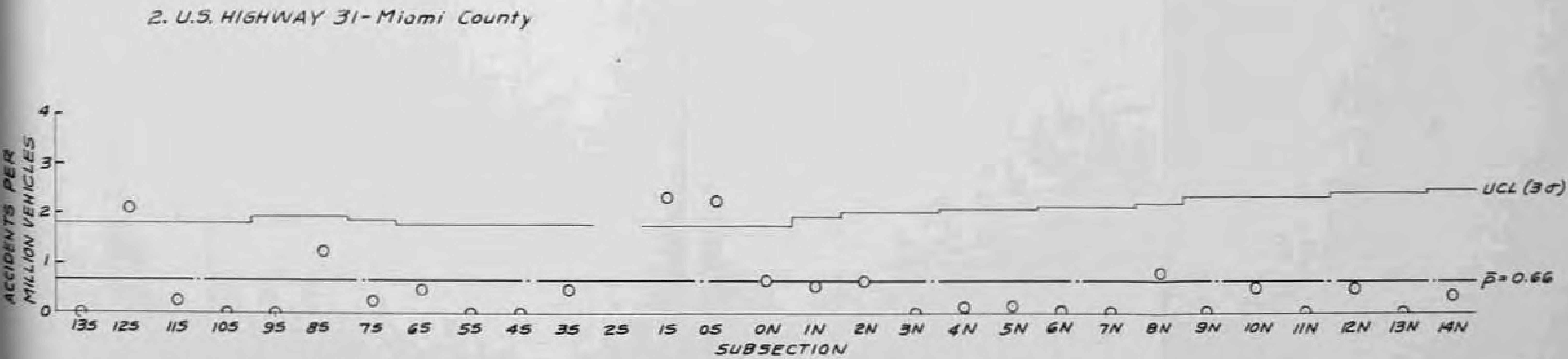
In general, all of the improvements recommended in this study are temporary measures which could be placed in effect within a short time, and which should reduce the accident rates at the features indicated. These improvements are not the final answer at all locations to a reduction of accidents at the features indicated on the test roads. This can only come with reconstruction of the features, and in some cases the facility, to modern and safe standards.



CONTROL CHARTS FOR TEST SECTIONS

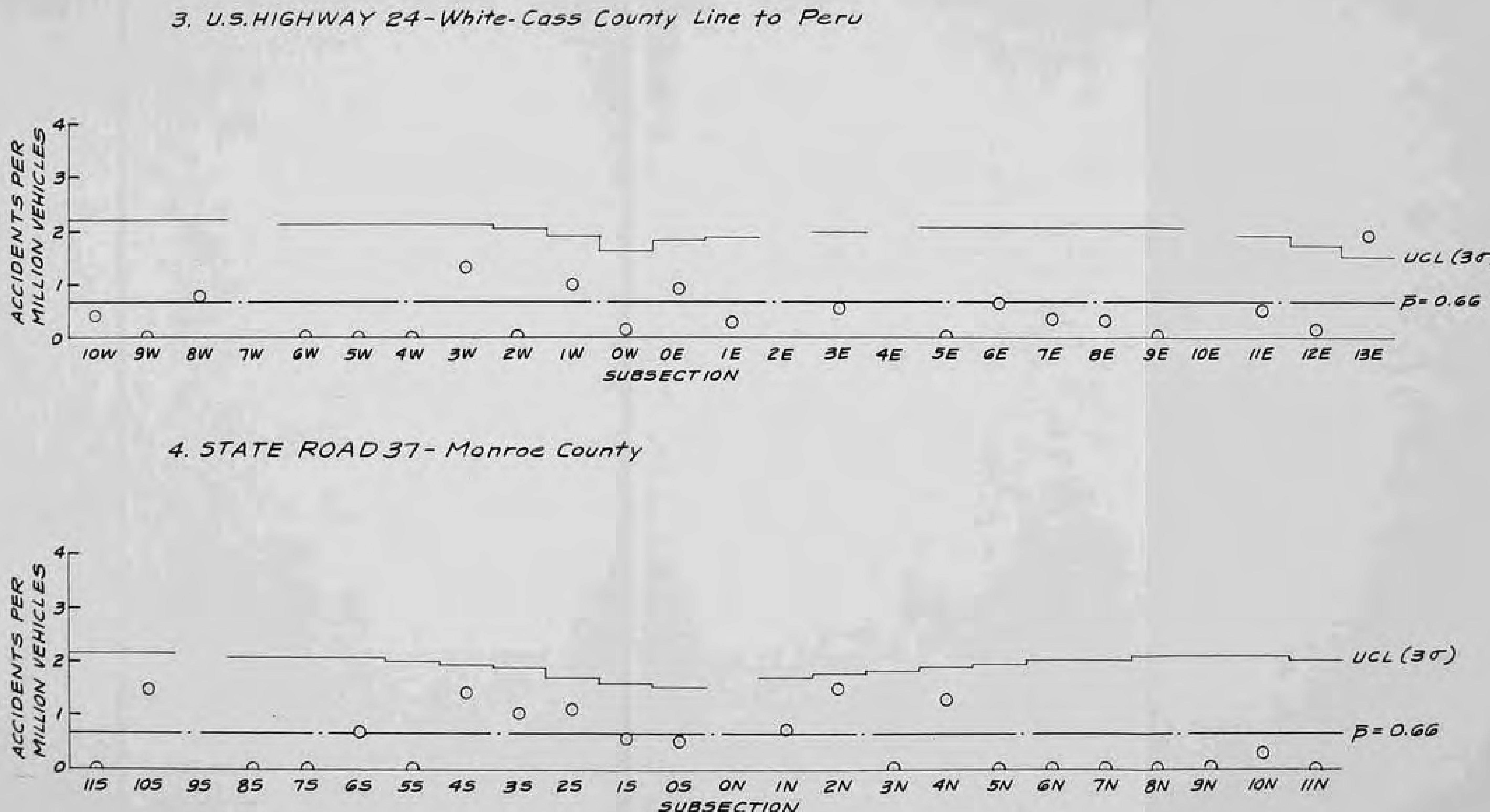
FIGURE 4





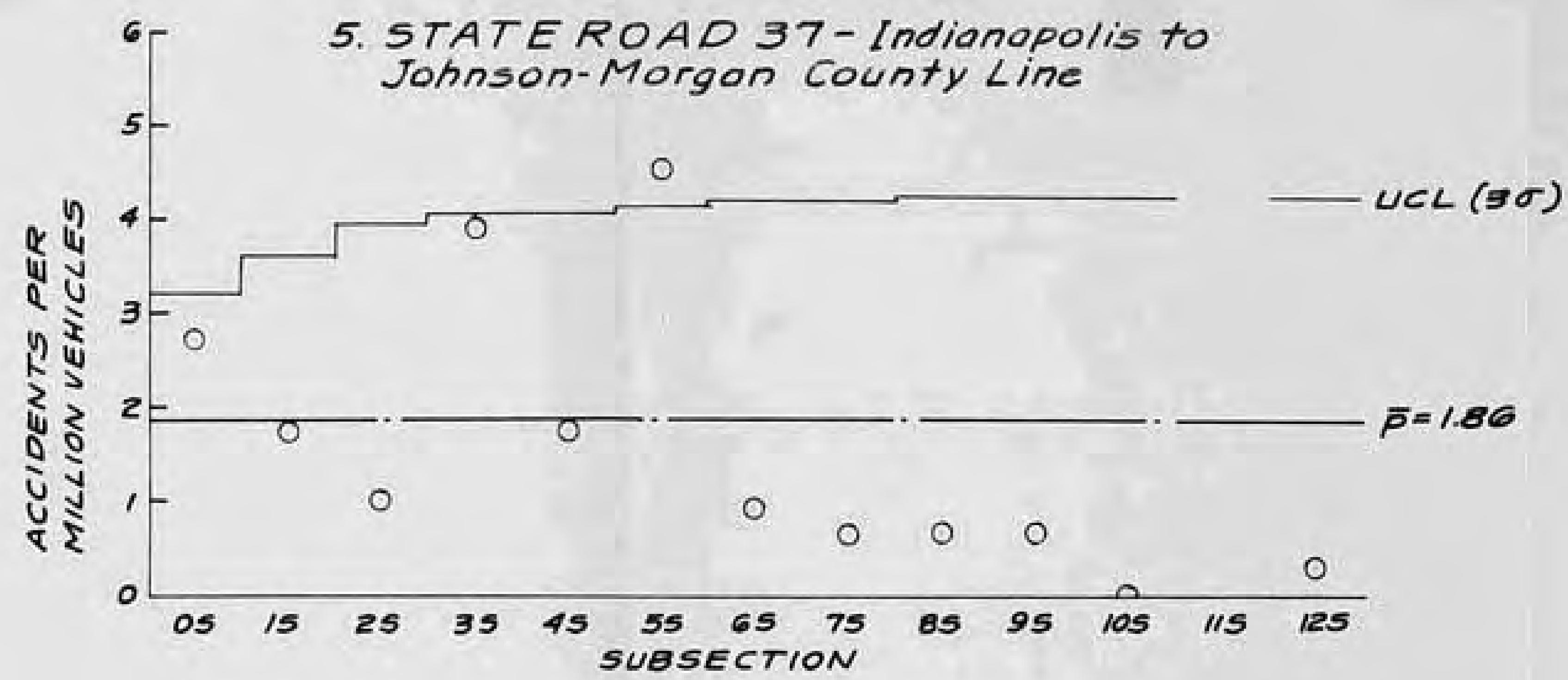
CONTROL CHARTS FOR ACCIDENTS AT INTERSECTIONS

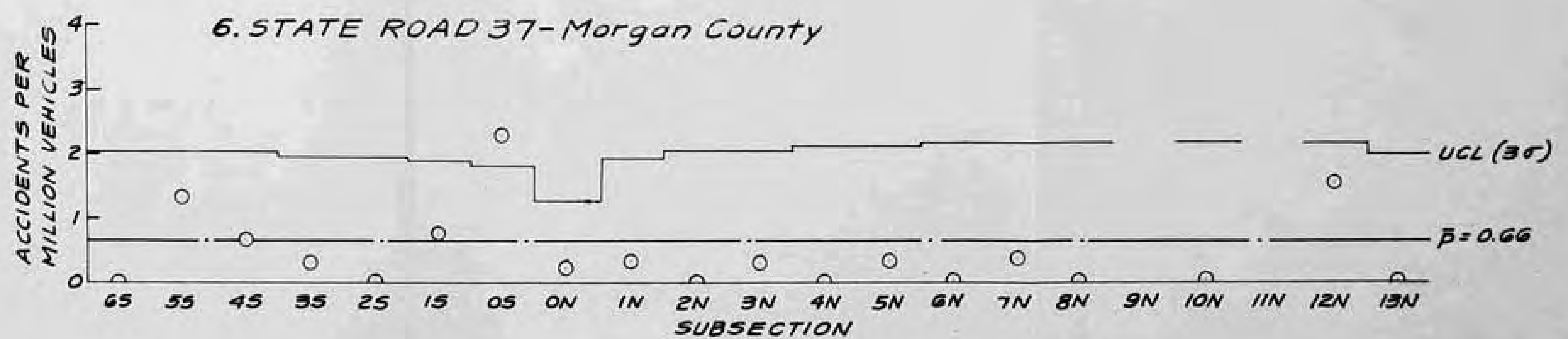
FIGURE 5



CONTROL CHARTS FOR ACCIDENTS AT INTERSECTIONS

FIGURE 6

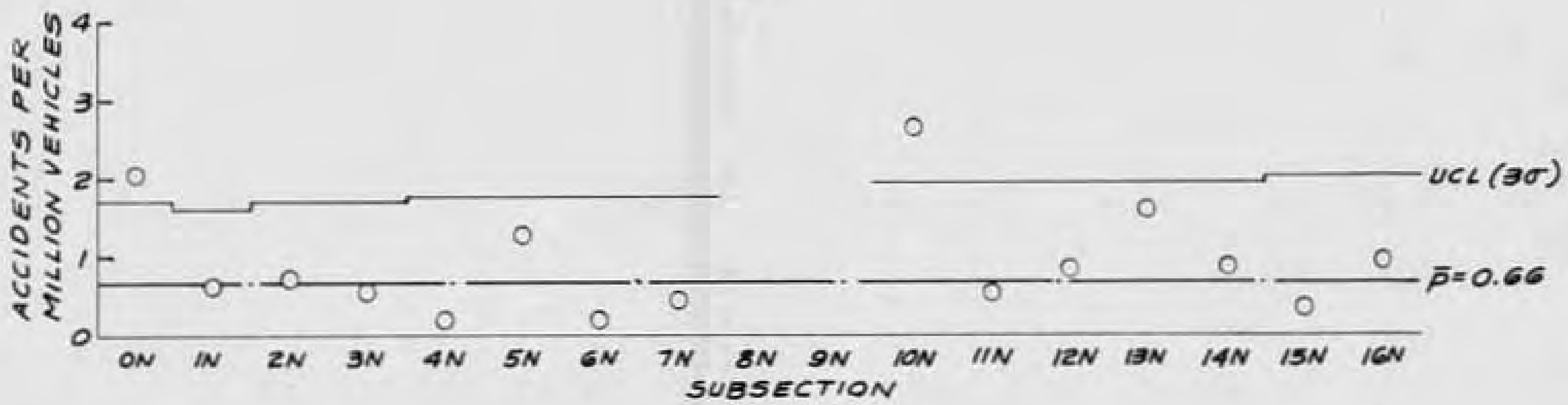




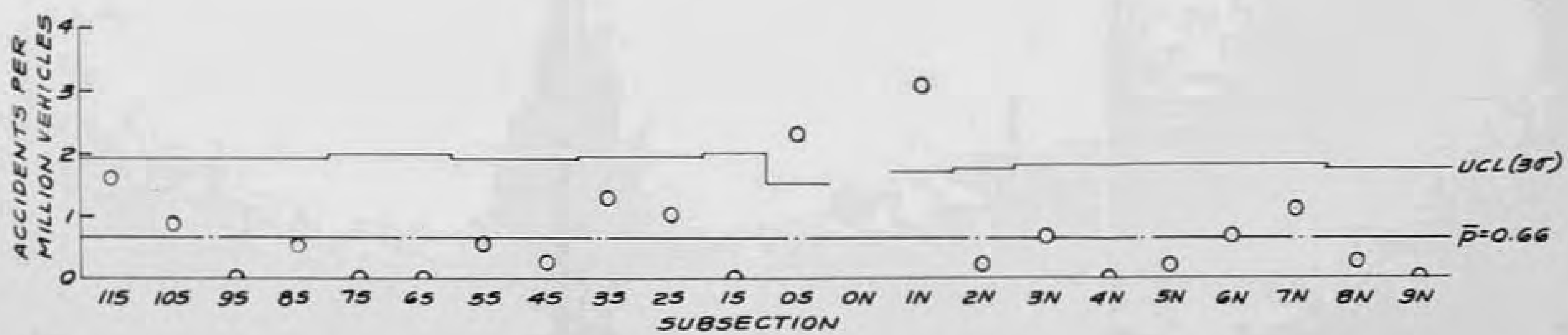
CONTROL CHARTS FOR ACCIDENTS AT INTERSECTIONS

FIGURE 7

7. STATE ROAD 9 - Anderson to Madison-Grant County Line



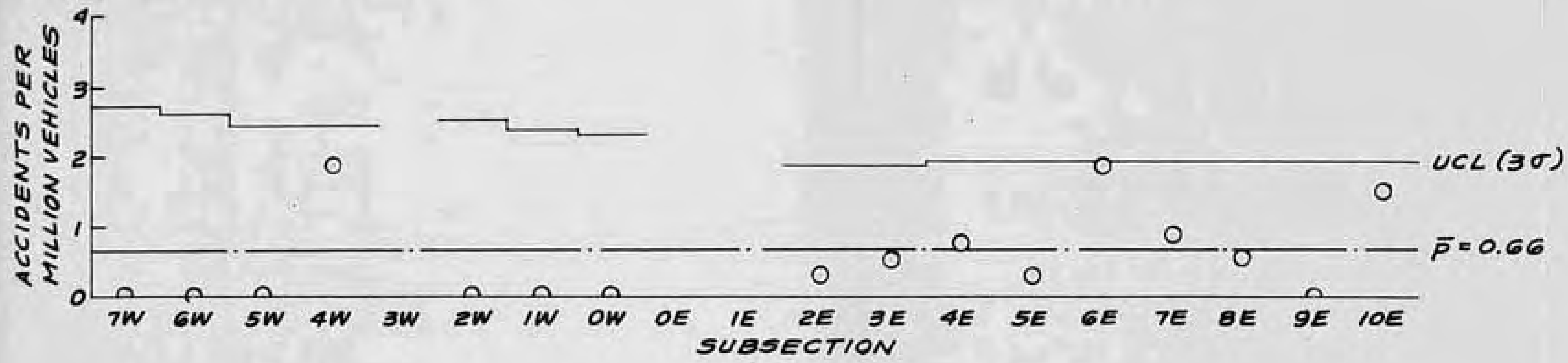
8. STATE ROAD 67 - Delaware County



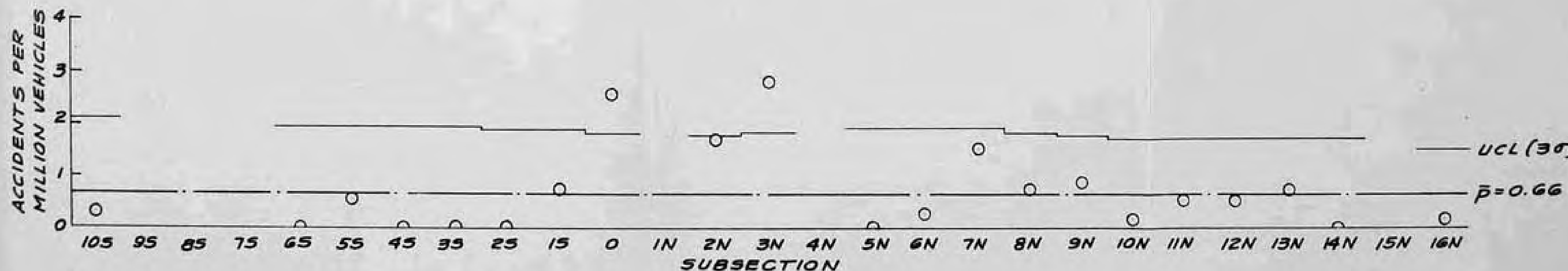
CONTROL CHARTS FOR ACCIDENTS AT INTERSECTIONS

FIGURE 8

9. U.S. HIGHWAY 36 - Hendricks County

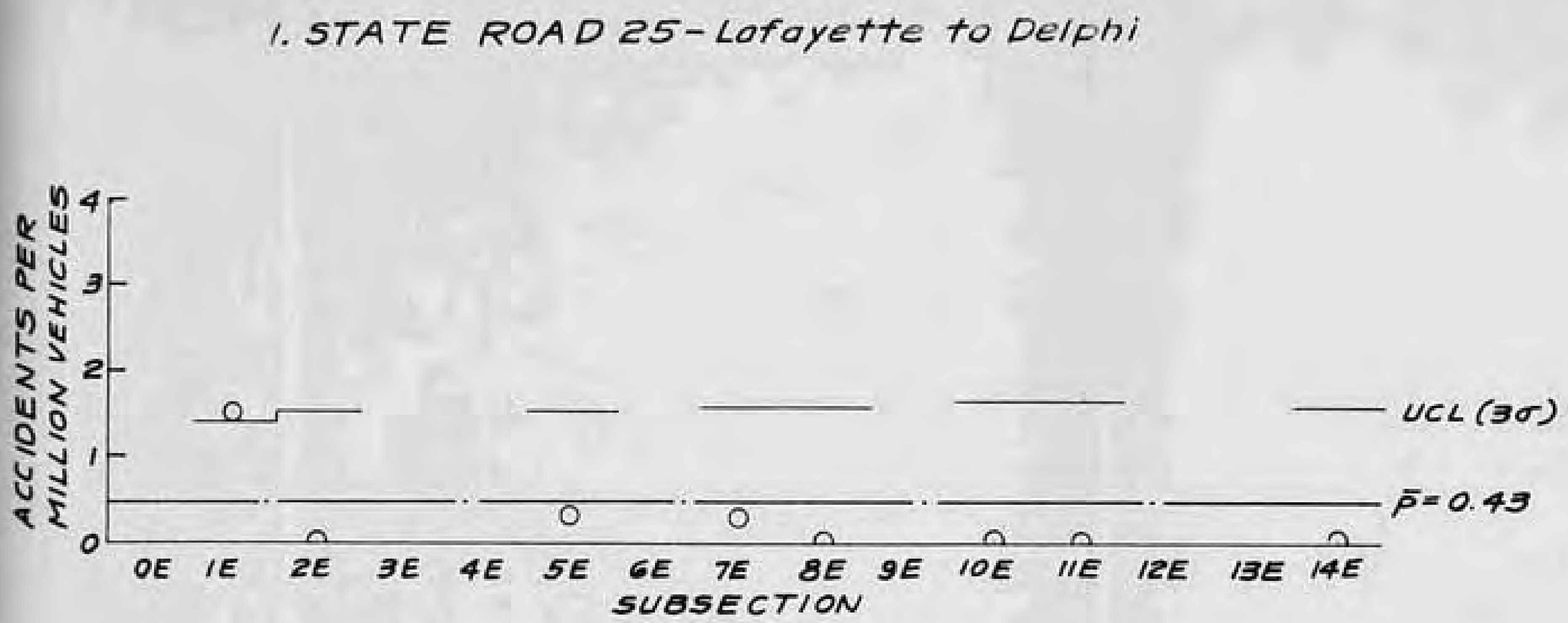


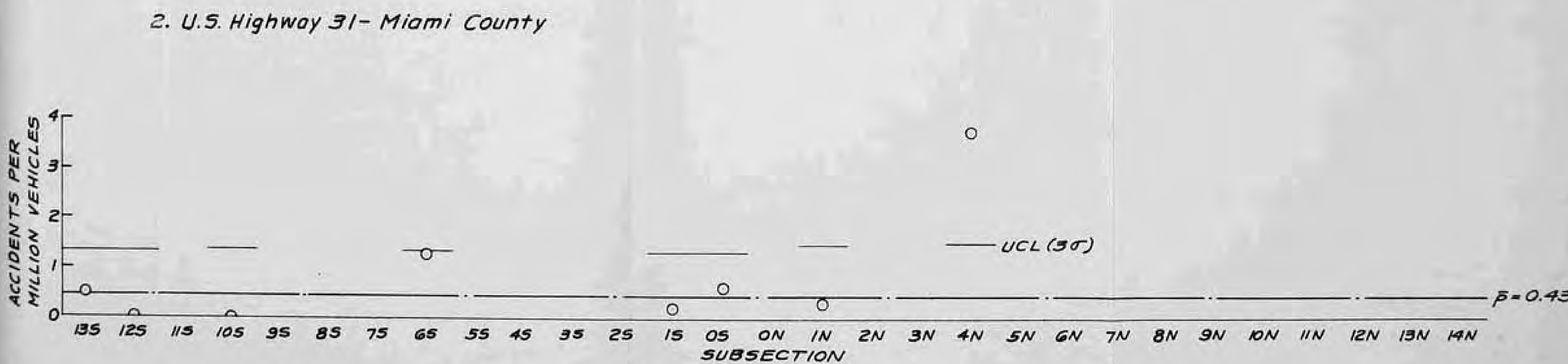
10. STATE ROAD 67 - Morgan County



CONTROL CHARTS FOR ACCIDENTS AT INTERSECTIONS

FIGURE 9

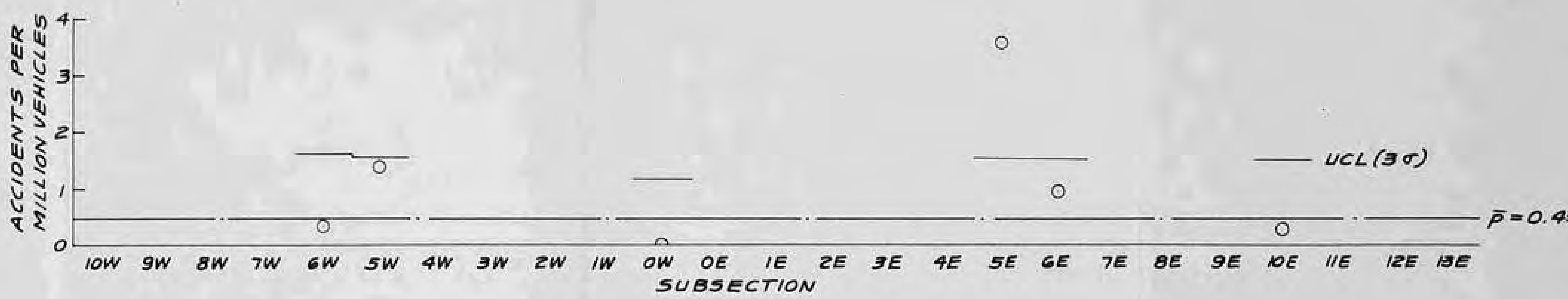




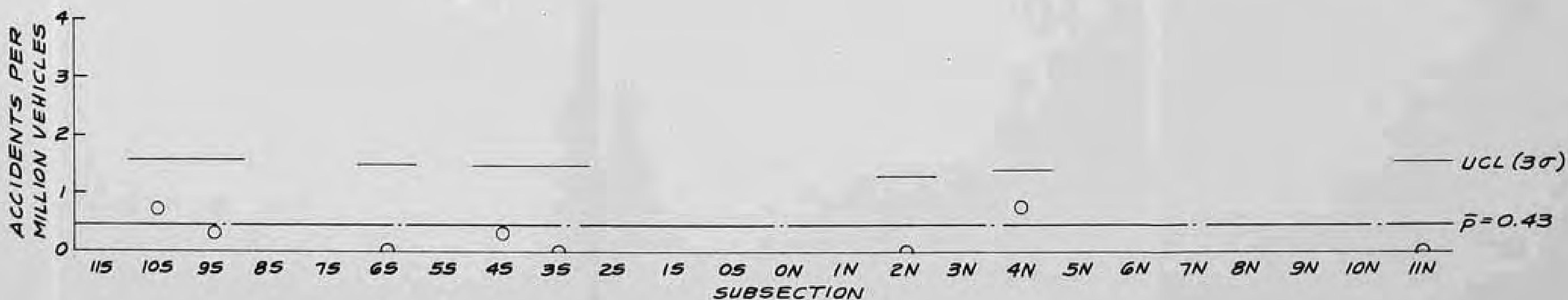
CONTROL CHARTS FOR ACCIDENTS AT STRUCTURES

FIGURE 10

3. U.S. HIGHWAY 24 - White-Cass County Line to Peru



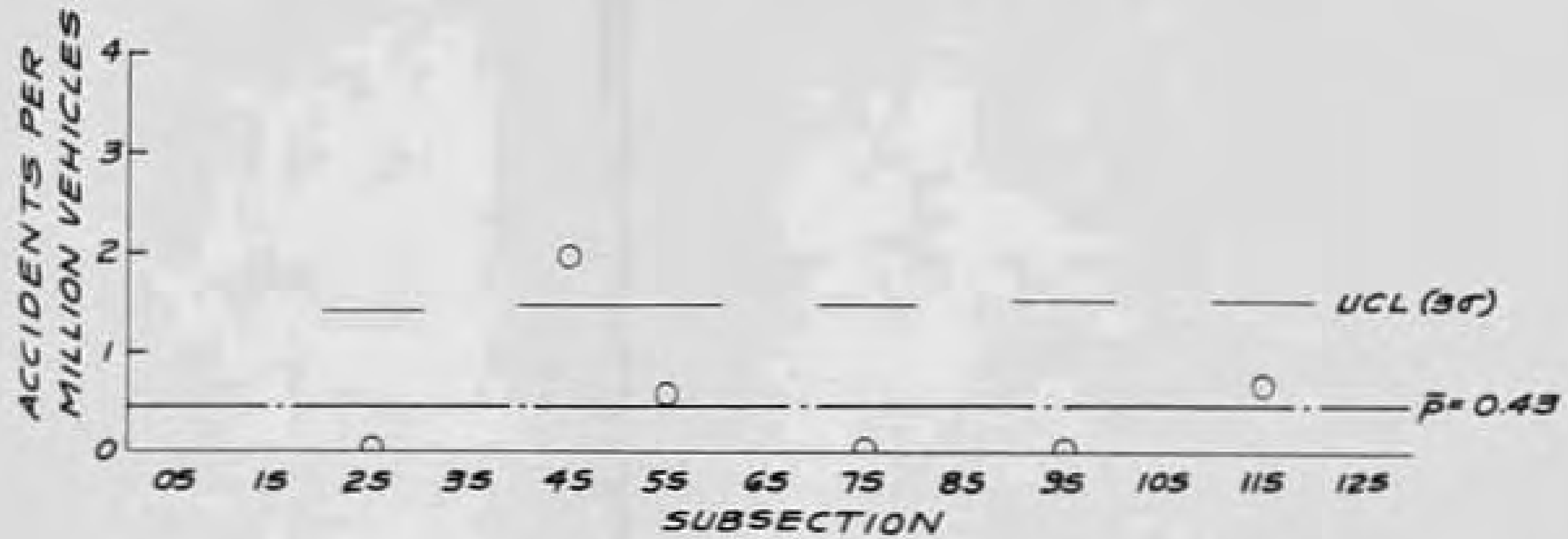
4. STATE ROAD 37 - Monroe County



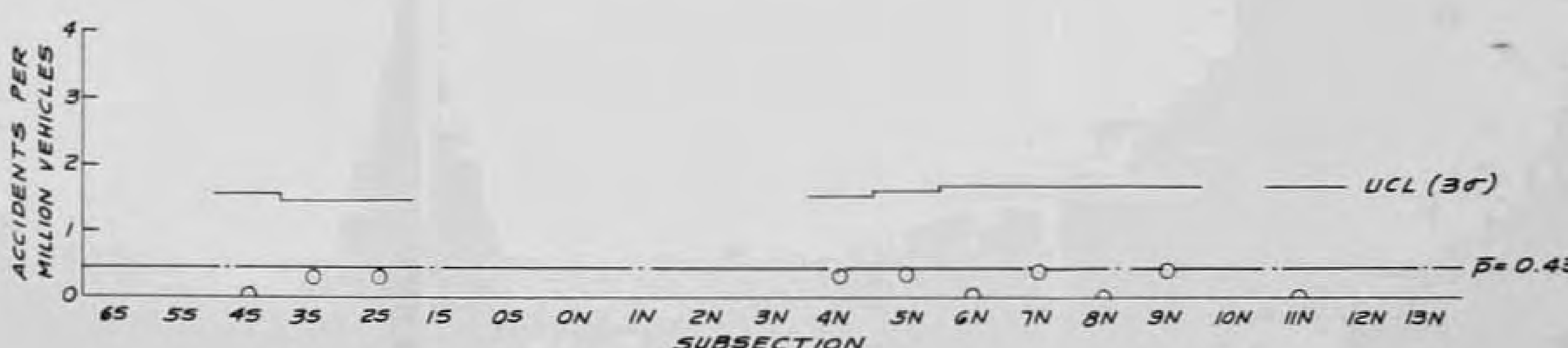
CONTROL CHARTS FOR ACCIDENTS AT STRUCTURES

FIGURE 11

5. STATE ROAD 37- Indianapolis to Johnson-Morgan County Line

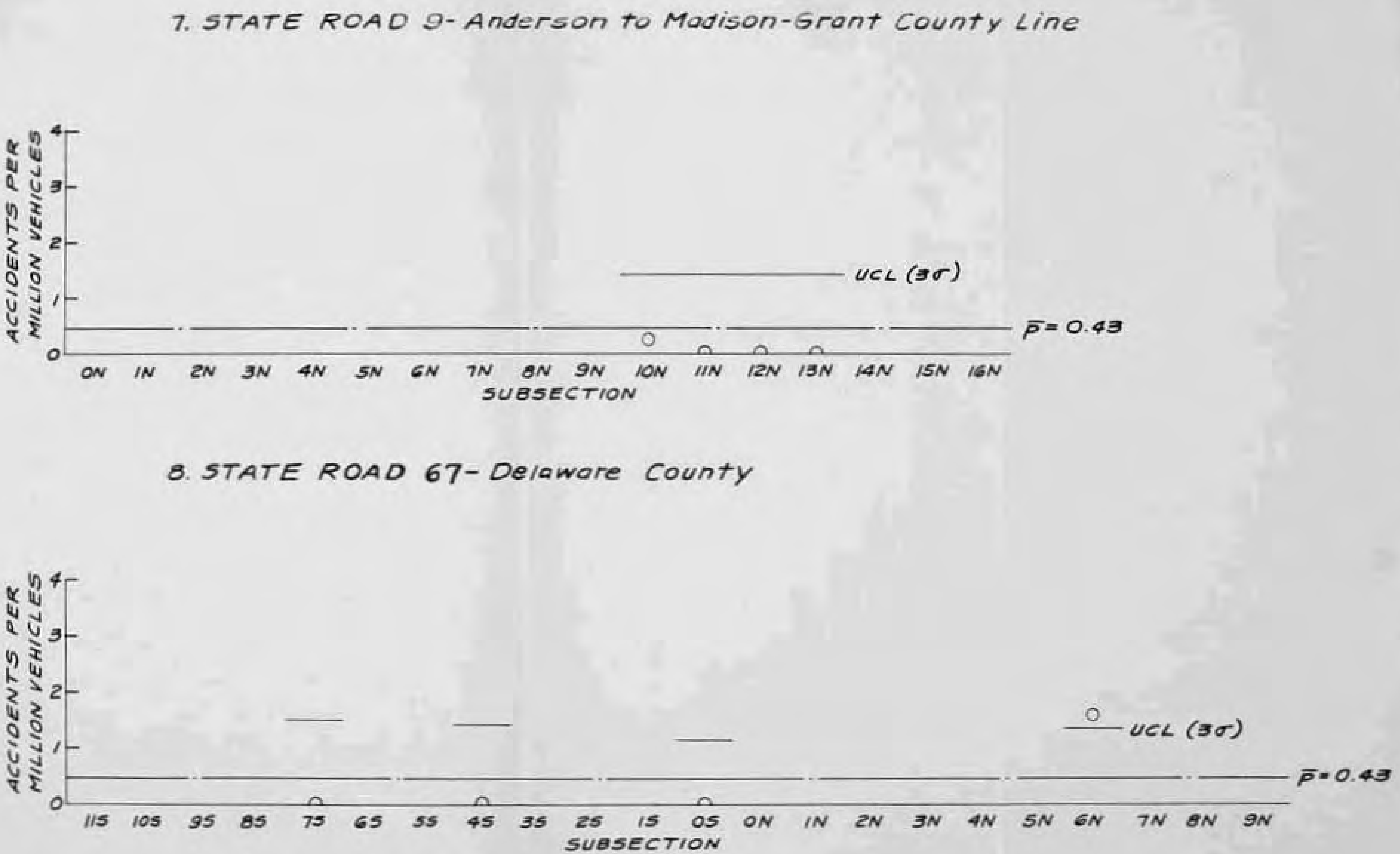


6. STATE ROAD 37- Morgan County



CONTROL CHARTS FOR ACCIDENTS AT STRUCTURES

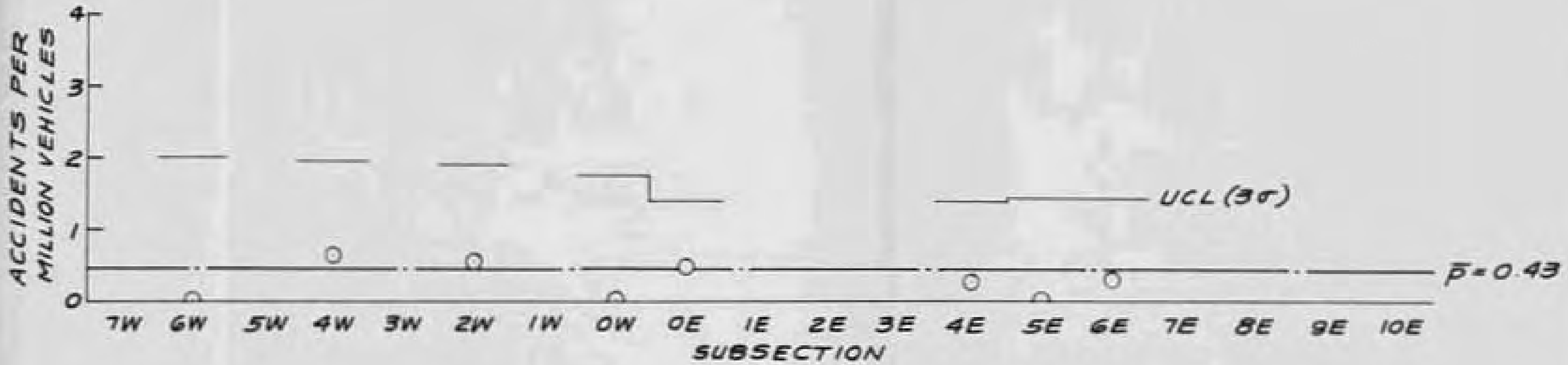
FIGURE 12



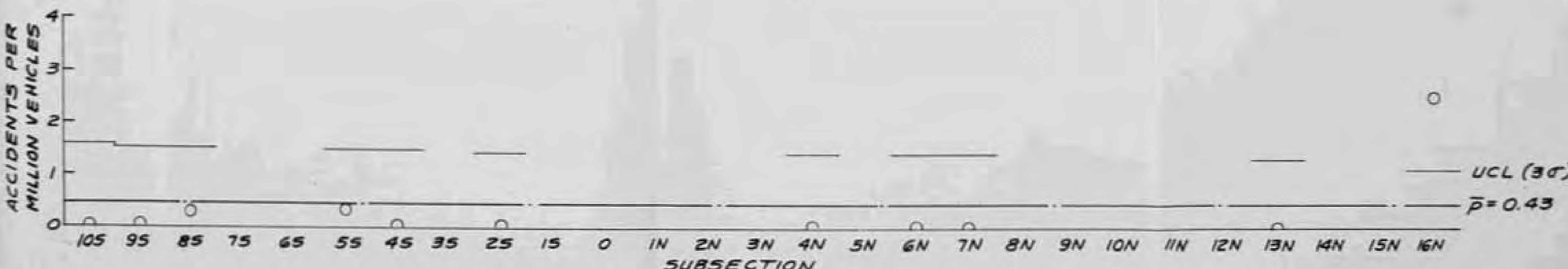
CONTROL CHARTS FOR ACCIDENTS AT STRUCTURES

FIGURE 13

9. U.S. HIGHWAY 36 - Hendricks County

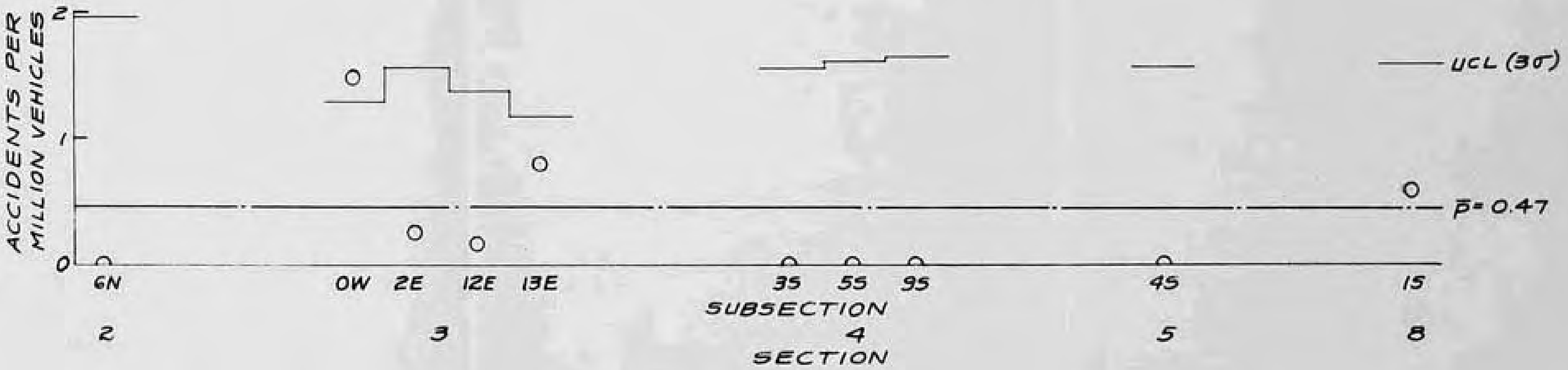


10. STATE ROAD 67 - Morgan County



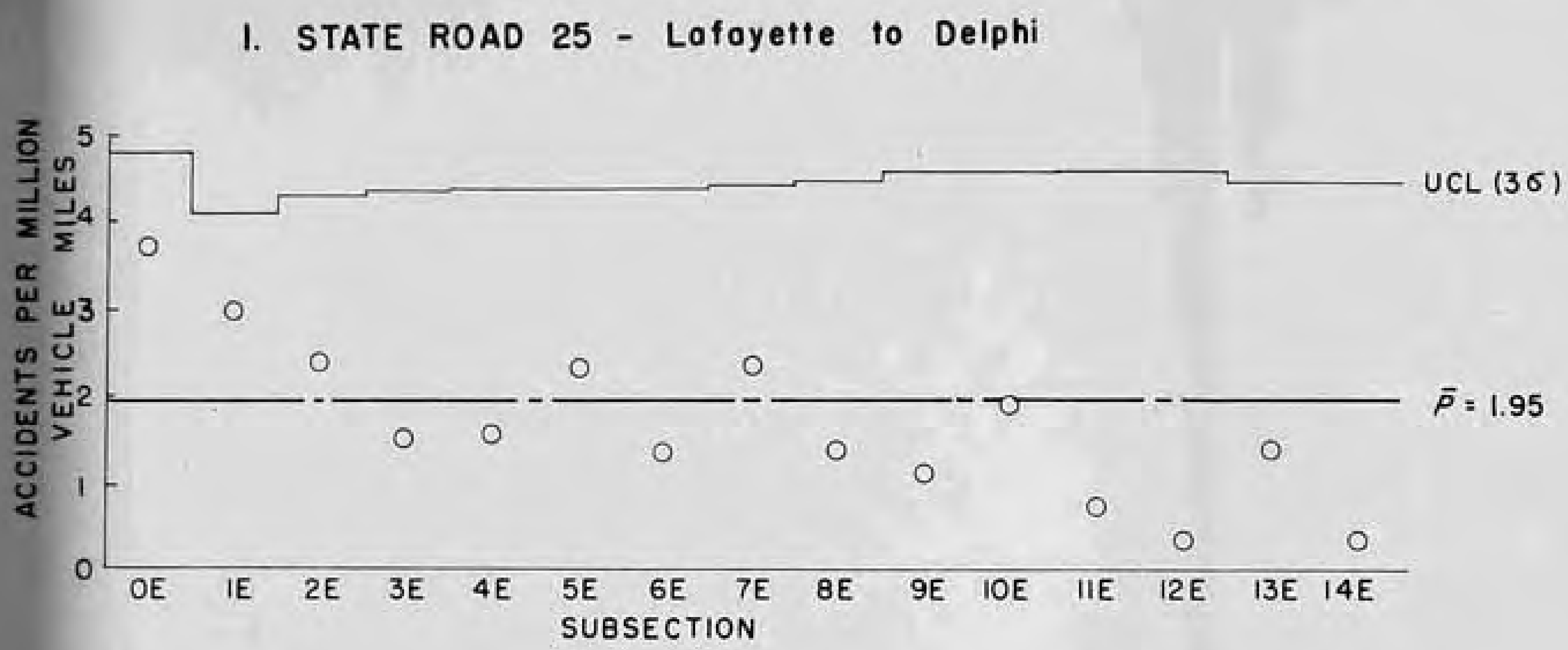
CONTROL CHARTS FOR ACCIDENTS AT STRUCTURES

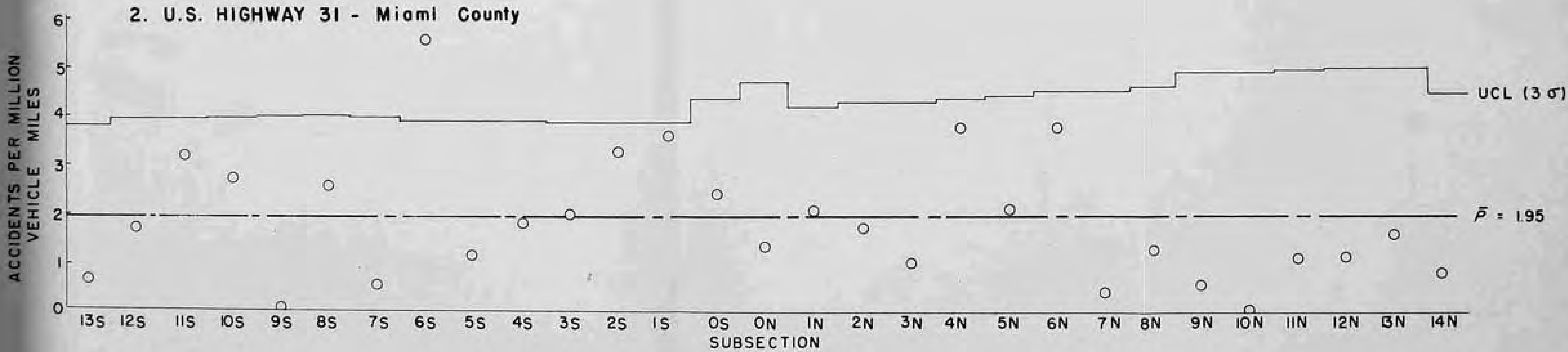
FIGURE 14



CONTROL CHART FOR ACCIDENTS AT RAILROAD CROSSINGS
ALL TEST SECTIONS

FIGURE 15



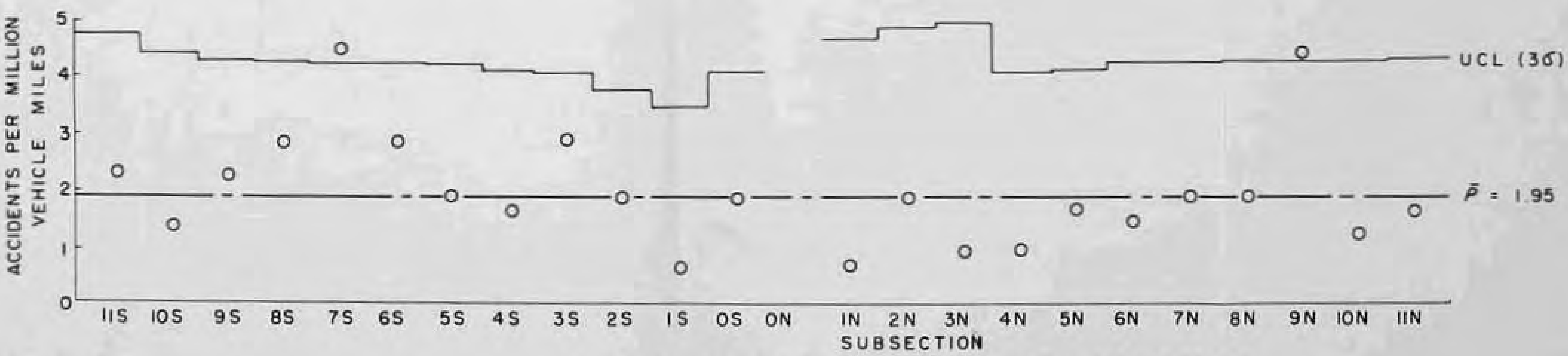


CONTROL CHARTS FOR OTHER ACCIDENTS

FIGURE 16

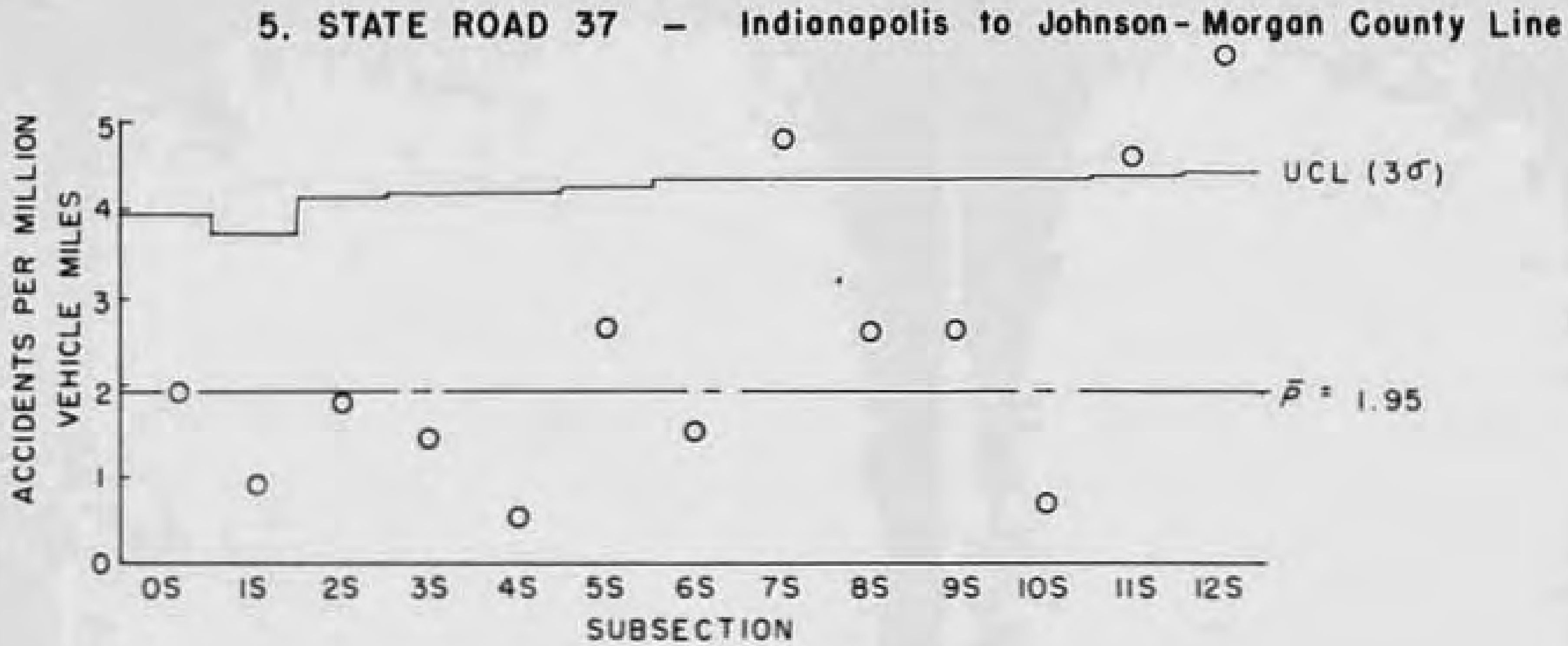
3. U.S. HIGHWAY 24- Cass-White County Line to Peru

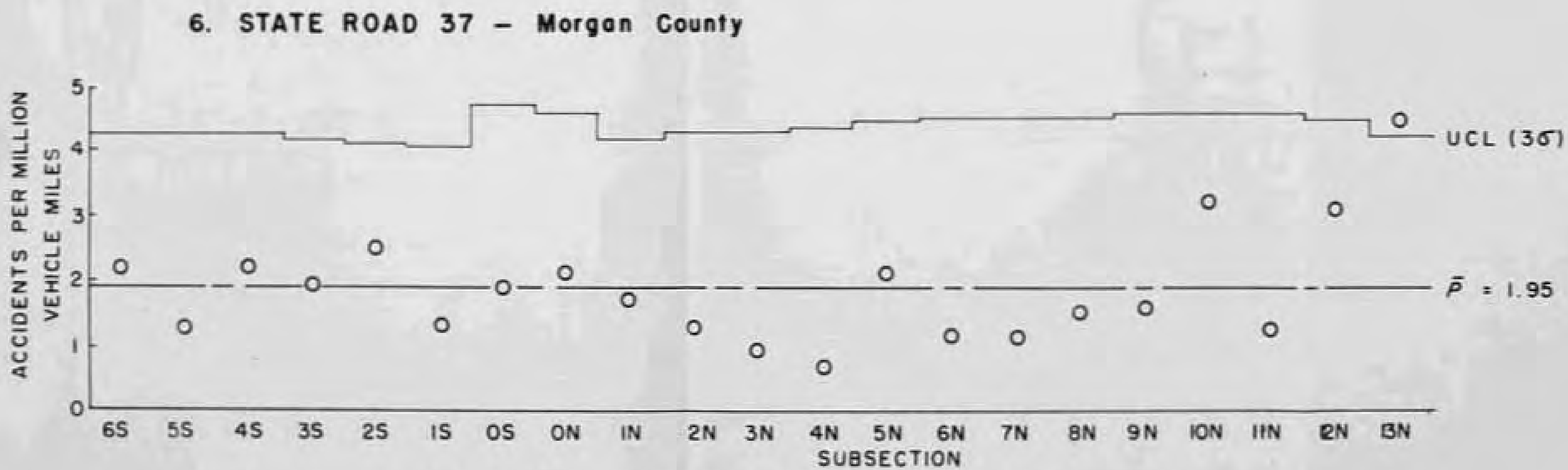
4. STATE ROAD 37 - Monroe County



CONTROL CHARTS FOR OTHER ACCIDENTS

FIGURE 17



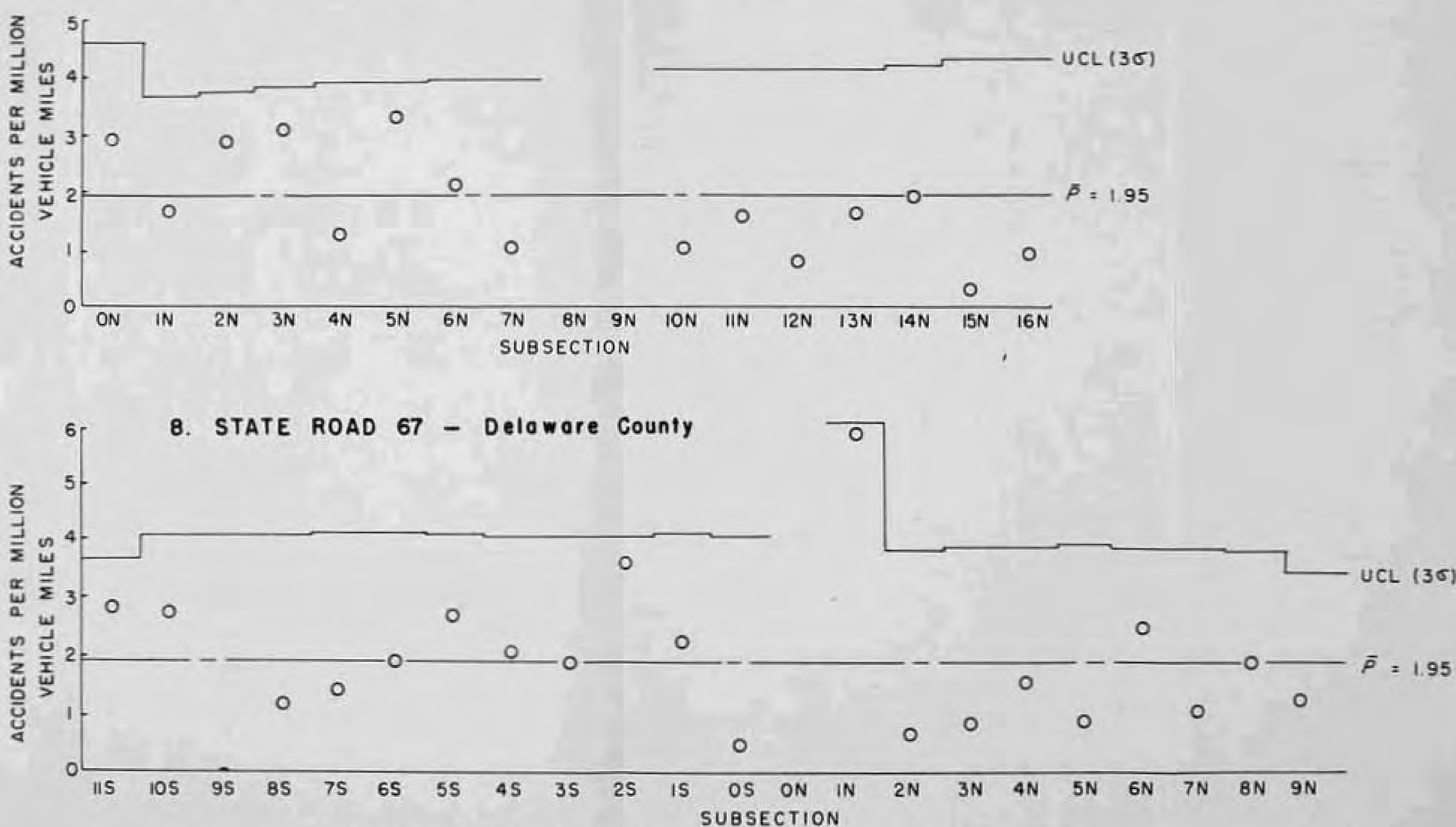


CONTROL CHARTS FOR OTHER ACCIDENTS

FIGURE 18

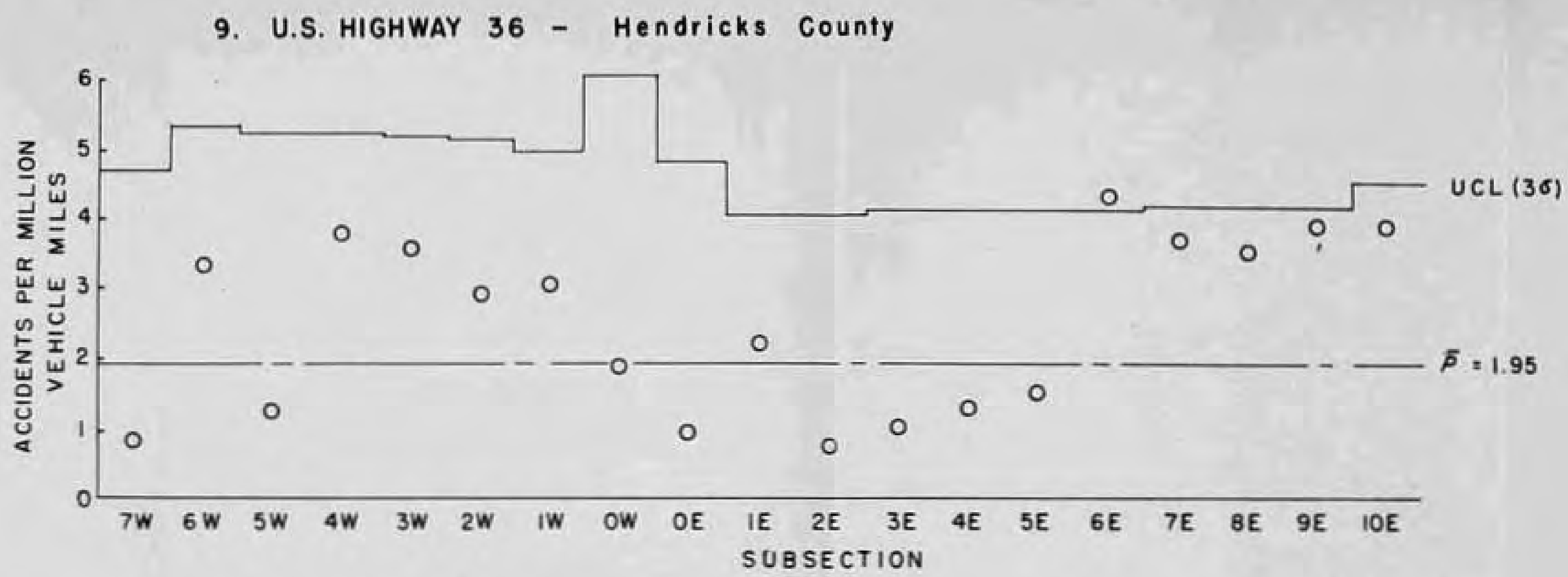
7. STATE ROAD 9 – Anderson to Madison-Grant County Line

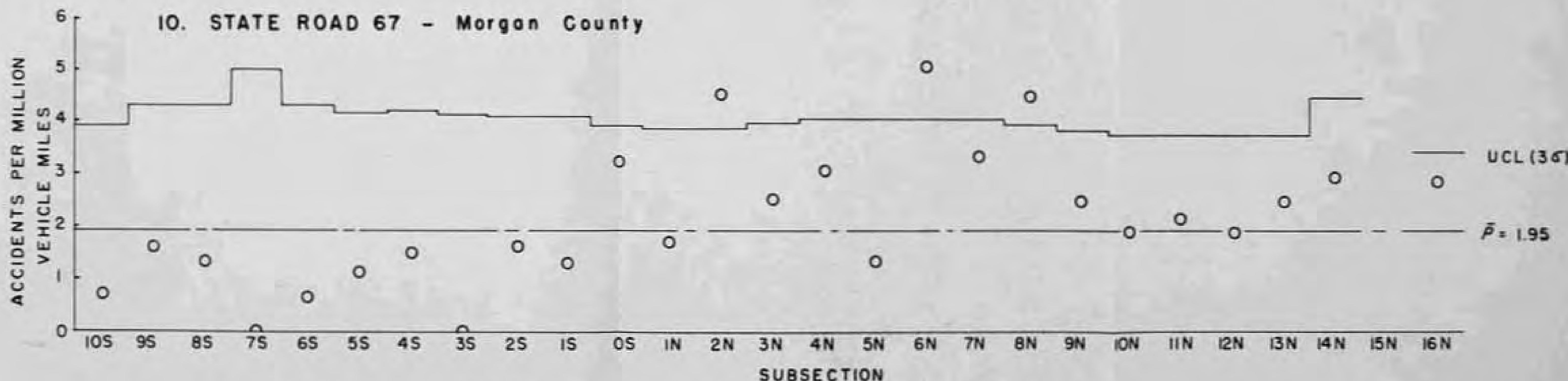
8. STATE ROAD 67 – Delaware County



CONTROL CHARTS FOR OTHER ACCIDENTS

FIGURE 19





CONTROL CHARTS FOR OTHER ACCIDENTS

FIGURE 20

Table 1

Subsections out of Control

Section	Subsection	Accidents at Intersections	Accidents at Structures	Accidents at RR X-ings	Other Accidents
1	0E	X			
1	1E		X		
1	5E	X			
1	14E	X			
2	0S	X			
2	1S	X			
2	6S				X
2	12S	X			
2	4N		X		
3	0W			X	
3	5E		X		
3	13E	X			
4	7S				X
4	9N				X
5	4S		X		
5	5S	X			
5	7S				X

Table 1 (continued)

Section	Subsection	Accidents at Intersections	Accidents at Structures	Accidents at RR X-ings	Other Accidents
5	11S				X
5	12S				X
6	0S	X			
6	13N				X
7	0N	X			
7	10N	X			
8	0S	X			
8	1N	X			
8	6N		X		
9	6E				X
10	0	X			
10	2N				X
10	3N	X			
10	6N				X
10	8N				X
10	16N		X		

Table 2

Recommendations for Specific Improvements on Out-of-Control Subsections*

Section 1 - SR 25 from Lafayette to Delphi

Subsection: 0E

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 25 and US 52.

Assignable Cause: Insufficient warning to motorists on SR 25 of traffic signal at intersection results in rear-end collisions (6 in 1956-57).

Recommendations: Install flasher warning signals and "Signals Ahead" sign on SR 25 on both sides of intersection.

Subsection: 1E

Type of Accident: At structures.

Feature where Accidents Occurred: Bridge at Wildcat Creek.

Assignable Cause: High speeds of motorists travelling toward Lafayette during periods of icing in vicinity of bridge results in loss-of-control accidents at bridge (6 in 1956-57).

Recommendations: Quick "deicing" maintenance during

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* For signing standards, see References 14 to 16 in Bibliography.

Table 2 (continued)

periods of freezing.

Subsection: 5E

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 25 and SR 225.

Assignable Cause: Lack of visibility on SR 25 west of intersection results in rear-end collisions with vehicles waiting to turn left onto SR 225 (8 in 1956-57).

Recommendations: Install a "Side Road" sign west of intersection, and construct a refuge lane for vehicles wishing to turn left from SR 25 to SR 225.

Subsection: 14E

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 25 and US 421.

Assignable Cause: The flat angle of divergence that must be used by vehicles wishing to turn left from SR 25 to US 421 results in head-on collisions with vehicles coming west from Delphi (2 in 1956-57) and rear-end collisions with vehicles travelling east on SR 25 (5 in 1956-57).

Recommendations: Construct a channelized T intersection with a refuge lane for vehicles wishing to turn left from SR 25 to US 421.

Table 2 (continued)

Section 2 - US 31 in Miami County

Subsection: 0S

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of US 31 and US 24.

Assignable Cause: The flat angle of convergence that must be used by vehicles on US 24 wishing to merge with traffic going east on US 31 results in head-on collisions with south-bound vehicles on US 31 (9 in 1956-57) and rear-end collisions with vehicles travelling east on US 24 (7 in 1956-57).

Recommendations: Construct a channelized T intersection and install a traffic signal to control the vehicle movements.

Subsection: 1S

Type of Accident: At intersections.

Feature where Accidents Occurred: This subsection included four intersections, and further study revealed none of the intersections to be especially hazardous.

Subsection: 6S

Type of Accident: Other.

Feature where Accidents Occurred: Approach to the Bunker Hill Air Force Base.

Table 2 (continued)

Assignable Cause: Extensive use of approach coupled with congested conditions on US 31 results in accidents caused by turning vehicles (20 in 1956-57).

Recommendations: Construct a channelized T intersection with provisions for an adequate deceleration lane for vehicles travelling south wishing to turn right and a refuge lane for vehicles travelling north wishing to turn left.

Subsection: 12S

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of US 31 and SR 18.

Assignable Cause: Conflicts between cross traffic results in right-angle collisions (6 in 1956-57).

Recommendations: Install oversize stop signs on SR 18 on both sides of intersection and "Cross Road" signs on US 31 on both sides of intersection.

Subsection: 4N

Type of Accident: At structures.

Feature where Accidents Occurred: Bridge at Eel River.

Assignable Cause: Extremely narrow width of bridge coupled with bad sight distance north of the structure results in accidents in bridge (11 in 1956-57).

Table 2 (continued)

Recommendations: Extend the 30 mph speed zone in Mexico south to include the bridge and illuminate the bridge and bridge approaches.

Section 3 - US 24 from White-Cass County Line to Peru

Subsection: 0W

Type of Accident: At railroad crossings.

Feature Where Accidents Occurred: Pennsylvania Railroad Crossing.

Assignable Cause: Advance warning signs on both sides of the railroad crossing not readily noticeable and placed too close to the actual crossing results in rear-end collisions during periods when vehicles are stopped for trains (10 in 1956-57).

Recommendations: Install additional measures of warning on both sides of railroad crossing.

Subsection: 5E

Type of Accident: At structures.

Feature Where Accidents Occurred: Overpass separating US 24 and Wabash Railroad.

Assignable Cause: Extremely narrow width of structure coupled with bad horizontal and vertical curvature west of structure results in accidents in structure (11 in 1956-57).

Recommendations: Speed zone US 24 in vicinity of

Table 2 (continued)

structure and inform motorists of hazardous narrow bridge well in advance of structure.

Subsection: 13E

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of US 24 and US 31 (This intersection is also on Subsection OS of Section 2 and is discussed there).

Section 4 - SR 37 in Monroe County

Subsection: 7S

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: General congestion coupled with bad horizontal and vertical curvature resulted in 14 accidents in 1956-57.

Recommendations: Speed zone entire subsection.

Subsection: 9N

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: None found.

Recommendations: None.

Section 5 - SR 37 from Indianapolis to Johnson-Morgan County Line

Table 2 (continued)

Subsection: 4S

Type of Accident: At structures.

Feature Where Accidents Occurred: Overpass separating SR 37 and Illinois Central Railroad.

Assignable Cause: Extremely narrow width of skew structure coupled with bad vertical curvature on both sides of structure results in accidents in structure (7 in 1956-57).

Recommendations: Speed zone SR 37 in vicinity of structure and inform motorists of hazardous narrow bridge well in advance of structure.

Subsection: 5S

Type of Accident: At intersections.

Feature Where Accidents Occurred: Intersection of SR 37 and Southport Road.

Assignable Cause: Very poorly signed intersection results in accidents between cross traffic (11 in 1956-57).

Recommendations: Improve marking of intersection by installing oversize "Stop" signs on Southport Road on both sides of intersection and "Cross Road" signs on SR 37.

Subsection: 7S

Type of Accident: Other.

Table 2 (continued)

Feature Where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Causes: None found.

Recommendations: None.

Subsection: 11S

Type of Accident: Other.

Feature where Accidents Occurred: Shockley's curve.

Assignable Cause: Extremely sharp curve at the end of a long tangent and a very slick pavement surface in the vicinity of the curve results in loss-of-control accidents (14 in 1956-57).

Recommendations: Speed zone SR 37 on both sides of curve and "deslick" pavement in vicinity of curve.

Subsection: 12S

Type of Accident: Other.

Feature where Accidents Occurred: Banta Road curve.

Assignable Cause: Very slick pavement surface in vicinity of curve when wet results in loss-of control accidents (7 in 1956-57).

Recommendations: Place "deslicking" material on pavement in vicinity of curve.

Section 6 - SR 37 in Morgan County

Subsection: 0S

Type of Accident: At intersections.

Table 2 (continued)

Feature where Accidents Occurred: This subsection included five intersections and further analysis revealed none of the intersections to be especially hazardous.

Subsection: 13N

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Causes: None found.

Recommendations: None.

Section 7 - SR 9 from Anderson to Madison-Grant County Line

Subsection: ON

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 9 and SR 109.

Assignable Cause: Present controls inadequate for vehicles wishing to turn left from SR 9 to SR 109 and right from SR 109 to SR 9 resulting in accidents involving turning vehicles (10 in 1956-57).

Recommendations: Construct a channelized T intersection with a refuge lane for vehicles wishing to turn left from SR 9 to SR 109 and an acceleration lane for vehicles wishing to turn from SR 109 to SR 9.

Table 2 (continued)

Subsection: 10N

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 9 and SR 28.

Assignable Cause: Conflicts between crossing and turning traffic resulted in 10 accidents in 1956-57.

Recommendations: Install additional warning measures well in advance of intersection on all approaches.

Section 8 - SR 67 in Delaware County

Subsection: 0S

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 67 and SR 3 and intersection of SR 67 and US 35. These intersections were not studied further because they are currently being reconstructed.

Subsection: 1N

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 67 and SR 3.

Assignable Cause: Warning sign north of intersection not readily distinguishable to motorists travelling toward Muncie results in rear-end collisions on

Table 2 (continued)

SR 67 (6 in 1956-57).

Recommendations: Improve warning measures for traffic travelling toward Muncie on SR 67.

Subsection: 6N

Type of Accident: At structures.

Feature where Accidents Occurred: Bridge at Mississinewa River. This location was not studied further because the bridge is currently being widened.

Section 9 - US 36 in Hendricks County

Subsection: 6E

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: General congestion partially due to many points of access results in accidents at points of access (10 in 1956-57).

Recommendations: Construct by-pass around town of Avon.

Section 10 - SR 67 in Morgan County

Subsection: 0

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of

Table 2 (continued)

SR 67 and SR 39E.

Assignable Cause: None found.

Recommendations: Intersection needs further study.

Subsection: 2N

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: Drivers take unnecessary chances in passing throughout this subsection because it is a level tangent, and adjacent subsections are fairly crooked with limited sight distance, partially caused by heavy vegetation on both sides of the road (21 accidents in 1956-57).

Recommendations: Obtain additional right-of-way on adjacent segments and clear vegetation to new right-of-way line.

Subsection: 3N

Type of Accident: At intersections.

Feature where Accidents Occurred: Intersection of SR 67 and SR 39W.

Assignable Cause: Lack of visibility south of intersection coupled with a very inconspicuous warning sign of intersection ahead causes rear-end collisions involving vehicles waiting to turn left from SR 67 to SR 39W (8 in 1956-57).

Table 2 (continued)

Recommendations: Install an oversize "Side Road" sign south of intersection, and construct a refuge lane for vehicles wishing to turn left from SR 67 to SR 39W.

Subsection: 6N

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: The subsection contains several horizontal curves which have limited sight distance and which cause accidents involving passing vehicles (13 in 1956-57).

Recommendations: Investigate all horizontal curves in this subsection to ascertain whether or not any curve requires the installation of a no-passing zone.

Subsection: 8N

Type of Accident: Other.

Feature where Accidents Occurred: Accidents distributed throughout subsection.

Assignable Cause: General congestion coupled with bad horizontal and vertical curvature resulted in 16 accidents in 1956-57.

Recommendations: Speed zone entire subsection.

Table 2 (continued)

Subsection: 16N

Type of Accident: At structures.

Feature where Accidents Occurred: The two bridges over tributaries of White Lick Creek.

Assignable Cause: The extremely narrow width of bridge results in accidents in the structures (18 in 1956-57).

Recommendations: Widen or reconstruct the bridges.

SUMMARY OF RESULTS

The following results were found from this study:

1. The application of the principle of quality control to the analysis of traffic accidents was found to be very useful in locating accident-prone subsections of highway, especially those containing single intersections, structures, and railroad crossings.

2. The element of risk as defined in this study was found to be a satisfactory unit of measure for traffic accidents.

3. For accidents at intersections, 15 out of 188 subsections containing intersections, or 8.0 percent, were out of control.

4. For accidents at structures, 6 out of 73 subsections containing structures, or 8.2 percent, were out of control.

5. For accidents at railroad crossings, 1 out of 10 subsections containing railroad crossings, or 10.0 percent, were out of control.

6. For other accidents, 11 out of 207 total subsections, or 5.3 percent, were out of control.

7. Assignable causes of accidents were found on 25 out of 33 out-of-control subsections involving all types of accidents. Of the eight subsections on which assignable causes were not determined, two were under construction at the time of the study and were eliminated from the analysis, and each of two others contained at least four

intersections, none of which were found to be unduly hazardous.

6. The absence of refuge lanes for left-turning vehicles from major highways; the absence of sufficient early warning to motorists approaching hazardous intersections or narrow structures; the lack of proper sight distance near intersections; the confusion resulting from large unchannelized intersections; and general congestion were found to be the major causes of accidents. Other causes, however, were also found on the various high-accident subsections. Table [illegible] gives assignable causes for accidents on all out-of-control subsections.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are a result of this study:

1. The application of the principle of quality control to the analysis of traffic accidents can be very useful in determining causes of accidents attributable to highway elements.

2. It is recommended that the improvements of highway elements which were found to contribute to the occurrence of traffic accidents and which are shown in Table 2 be considered for inclusion in improvement programs on Indiana highways.

3. It is recommended that the quality control type of accident analysis be applied to highways in Indiana on a much larger scale than was possible in this study.

4. It is suggested that, several years after the recommendations for specific improvements made in this study are put into effect by the Indiana Highway Department, an "after" study be conducted to ascertain the effectiveness of those improvements in reducing accident rates.

BIBLIOGRAPHY

1. Accident Facts, Annual Publication, National Safety Council, Chicago, 1955.

2. McMonagle, J. Carl, "Accident Analysis - Telegraph Road 1947-1948," Bulletin 30 Highway Research Board, 1951.

3. Raff, Morton S., "Interstate Highway - Accident Study," Bulletin 74 Highway Research Board, 1953.

4. Schoppert, David W., "Predicting Traffic Accidents from Roadway Elements of Rural Two-Lane Highways with Gravel Shoulders," Bulletin 158 Highway Research Board, 1957.

5. Williams, S. J., and Fritts, C. E., "Let's Build Safety Into Our Highways," Public Safety, May, 1955.

6. May, Adolph D., "An Evaluation of Certain Limited Access Highways," A Thesis submitted to the faculty of Purdue University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Civil Engineering, January, 1955.

7. Woo, John C. H., "Correlation of Accident Rates and Roadway Factors," A Thesis submitted to the faculty of Purdue University in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering, August, 1957.

8. Belmont, D. M., "Accidents versus Width of Paved Shoulders on California Two-Lane Tangents - 1951 and 1952," Bulletin 117 Highway Research Board, 1956.

9. Woo, John C. H., "Correlation of Accident Rates and Roadway Factors," A Progress Report presented to the Joint Highway Research Project, July 24, 1957.

10. Halsey, Maxwell, Traffic Accidents and Congestion, New York, John Wiley and Sons, Inc., 1941.

11. Nordon, Monroe; Orlansky, Jesse; and Jacobs, Herbert; "Application of Statistical Quality Control Techniques to Analysis of Highway Accident Data," Bulletin 117 Highway Research Board, 1956.

12. Mathewson, J. H., and Brenner, R., "Indexes of Motor Vehicle Accident Likelihood," Bulletin 161 Highway Research Board, 1957.

13. Burr, Irving W., "Engineering Statistics and Quality Control," McGraw-Hill Book Company, Inc., New York, N. Y., 1953, pp. 91-92 and pp. 214-218.

14. Public Roads Administration, Manual on Uniform Traffic Control Devices for Streets and Highways, Public Roads Administration, Section 09, 1948.

15. Bureau of Public Roads, Revisions to the Manual on Uniform Traffic Control Devices for Streets and Highways, Bureau of Public Roads, Section 58, 1954.

16. State Highway Department of Indiana, Manual on Uniform Traffic Control Devices for Streets and Highways, State Highway Department of Indiana, Volumes 1 and 2, 1958.

APPENDIX

DESCRIPTIONS OF SUBSECTIONS

Table 1A

Table Giving Descriptions of Subsections

Section 1 - State Road 25 from Lafayette to Delphi

Subsection	Length-Miles	Description
0E	0.5	0.0 to 0.5 miles east of Lafayette
1E	1.0	0.5 to 1.5 " " " "
2E	1.0	1.5 to 2.5 " " " "
3E	1.0	2.5 to 3.5 " " " "
4E	1.0	3.5 to 4.5 " " " "
5E	1.0	4.5 to 5.5 " " " "
6E	1.0	5.5 to 6.5 " " " "
7E	1.0	6.5 to 7.5 " " " "
8E	1.0	7.5 to 8.5 " " " "
9E	1.0	8.5 to 9.5 " " " "
10E	1.0	9.5 to 10.5 " " " "
11E	1.0	10.5 to 11.5 " " " "
12E	1.0	11.5 to 12.5 " " " "
13E	1.0	12.5 to 13.5 " " " "
14E	1.0	13.5 miles east of Lafayette to west city limits of Delphi
	14.5	

Note: East of Lafayette means east of the east city limits.

Table 1A (continued)

Section 2 - U.S. Highway 31 in Miami County

Subsection	Length-Miles	Description
0S	0.5	0.0 to 0.5 miles south of Peru
1S	1.0	0.5 to 1.5 " " " "
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "
6S	1.0	5.5 to 6.5 " " " "
7S	1.0	6.5 to 7.5 " " " "
8S	1.0	7.5 to 8.5 " " " "
9S	1.0	8.5 to 9.5 " " " "
10S	1.0	9.5 to 10.5 " " " "
11S	1.0	10.5 to 11.5 " " " "
12S	1.0	11.5 to 12.5 " " " "
13S	1.0	12.5 miles south of Peru to Miami-Howard County line
0N	0.5	0.0 to 0.5 miles north of Peru
1N	1.0	0.5 to 1.5 " " " "
2N	1.0	1.5 to 2.5 " " " "
3N	1.0	2.5 to 3.5 " " " "
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "
6N	1.0	5.5 to 6.5 " " " "
7N	1.0	6.5 to 7.5 " " " "
8N	1.0	7.5 to 8.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
9N	1.0	8.5 to 9.5 miles north of Peru
10N	1.0	9.5 to 10.5 " " " "
11N	1.0	10.5 to 11.5 " " " "
12N	1.0	11.5 to 12.5 " " " "
13N	1.0	12.5 to 13.5 " " " "
14N	1.5	13.5 miles north of Peru to Miami-Fulton County line
	20.6	

Note: South of Peru means southwest of the west city limits. North of Peru means north of the north city limits.

Section 3 - U.S. Highway 31 from Cass-White County Line to Peru

Subsection	Length-Miles	Description
0W	0.5	0.0 to 0.5 miles west of Logansport
1W	1.0	0.5 to 1.5 " " " "
2W	1.0	1.5 to 2.5 " " " "
3W	1.0	2.5 to 3.5 " " " "
4W	1.0	3.5 to 4.5 " " " "
5W	1.0	4.5 to 5.5 " " " "
6W	1.0	5.5 to 6.5 " " " "
7W	1.0	6.5 to 7.5 " " " "
8W	1.0	7.5 to 8.5 " " " "
9W	1.0	8.5 to 9.5 " " " "
10W	1.0	9.5 miles west of Logansport to Cass-White County line
0E	0.5	0.0 to 0.5 miles east of Logansport
1E	1.0	0.5 to 1.5 " " " "
2E	1.0	1.5 to 2.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
3E	1.0	2.5 to 3.5 miles east of Logansport
4E	1.0	3.5 to 4.5 " " " "
5E	1.0	4.5 to 5.5 " " " "
6E	1.0	5.5 to 6.5 " " " "
7E	1.0	6.5 to 7.5 " " " "
8E	1.0	7.5 to 8.5 " " " "
9E	1.0	8.5 to 9.5 " " " "
10E	1.0	9.5 to 10.5 " " " "
11E	1.0	10.5 to 11.5 " " " "
12E	1.0	11.5 to 12.5 " " " "
13E	0.5	12.5 miles east of Logansport to west city limits of Peru
	23.5	

Note: West of Logansport means west of the west city limits.
East of Logansport means east of the east city limits.

Section 4 - State Road 37 in Monroe County

Subsection	Length-Miles	Description
0S	0.5	0.0 to 0.5 miles south of Bloomington
1S	1.0	0.5 to 1.5 " " " "
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "
6S	1.0	5.5 to 6.5 " " " "
7S	1.0	6.5 to 7.5 " " " "
8S	1.0	7.5 to 8.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
9S	1.0	8.5 to 9.5 miles south of Bloomington
10S	1.0	9.5 to 10.5 " " " "
11S	0.8	10.5 miles south of Bloomington to Monroe-Lawrence County line
1N	1.0	0.5 to 1.5 miles north of Bloomington
2N	1.0	1.5 to 2.5 " " " "
3N	1.0	2.5 to 3.5 " " " "
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "
6N	1.0	5.5 to 6.5 " " " "
7N	1.0	6.5 to 7.5 " " " "
8N	1.0	7.5 to 8.5 " " " "
9N	1.0	8.5 to 9.5 " " " "
10N	1.0	9.5 to 10.5 " " " "
11N	1.0	10.5 miles north of Bloomington to Monroe-Morgan County line
	22.3	

Note: South of Bloomington means south of the south city limits. North of Bloomington means north of the north city limits.

Section 5 - State Road 37 from Indianapolis to Johnson-Morgan County Line

Subsection	Length-Miles	Description
0S	0.5	0.0 to 0.5 miles south of Indianapolis
1S	1.0	0.5 to 1.5 " " " "
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
6S	1.0	5.5 to 6.5 miles south of Indianapolis
7S	1.0	6.5 to 7.5 " " " "
8S	1.0	7.5 to 8.5 " " " "
9S	1.0	8.5 to 9.5 " " " "
10S	1.0	9.5 to 10.5 " " " "
11S	1.0	10.5 to 11.5 " " " "
12S	0.9	11.5 miles south of Indianapolis to Johnson-Morgan County line
	12.4	

Note: South of Indianapolis means south of the south city limits.

Section 6 - State Road 37 in Morgan County

Subsection	Length-Miles	Description
0S	0.5	0.0 to 0.5 miles south of Martinsville
1S	1.0	0.5 to 1.5 " " " "
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "
6S	1.3	5.5 miles south of Martinsville to Morgan-Monroe County line
0N	0.5	0.0 to 0.5 miles north of Martinsville
1N	1.0	0.5 to 1.5 " " " "
2N	1.0	1.5 to 2.5 " " " "
3N	1.0	2.5 to 3.5 " " " "
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
6N	1.0	5.5 to 6.5 miles north of Martinsville
7N	1.0	6.5 to 7.5 " " " "
8N	1.0	7.5 to 8.5 " " " "
9N	1.0	8.5 to 9.5 " " " "
10N	1.0	9.5 to 10.5 " " " "
11N	1.0	10.5 to 11.5 " " " "
12N	1.0	11.5 to 12.5 " " " "
13N	1.1	12.5 miles north of Martinsville to Morgan-Johnson County line
	20.4	

Note: South of Martinsville means south of the south city limits. North of Martinsville means north of the north city limits.

Section 7 - State Road 9 from Anderson to Madison-Grant County Line

Subsection	Length-Miles	Description
0N	0.5	0.0 to 0.5 miles north of Anderson
1N	1.0	0.5 to 1.5 " " " "
2N	1.0	1.5 to 2.5 " " " "
3N	1.0	2.5 to 3.5 " " " "
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "
6N	1.0	5.5 to 6.5 " " " "
7N	0.9	6.5 miles north of Anderson to south city limits of Alexandria
10N	1.0	From north city limits of Alexandria to 10.5 miles north of Anderson
11N	1.0	10.5 to 11.5 miles north of Anderson

Table 1A (continued)

Subsection	Length-Miles	Description
12N	1.0	11.5 to 12.5 miles north of Anderson
13N	1.0	12.5 to 13.5 " " " "
14N	1.0	13.5 to 14.5 " " " "
15N	1.0	14.5 to 15.5 " " " "
16N	1.0	15.5 miles north of Anderson to Madison-Grant County line
	14.4	

Note: North of Anderson means north of the north city limits.

Section 8 - State Road 67 in Delaware County

Subsection	Length-Miles	Description
0S	0.5	0.0 to 0.5 miles south of Muncie
1S	1.0	0.5 to 1.5 " " " "
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "
6S	1.0	5.5 to 6.5 " " " "
7S	1.0	6.5 to 7.5 " " " "
8S	1.0	7.5 to 8.5 " " " "
9S	1.0	8.5 to 9.5 " " " "
10S	1.0	9.5 to 10.5 " " " "
11S	1.5	10.5 miles south of Muncie to Delaware-Madison County line
1N	0.2	From north intersection of Sr 67 and U.S 3 to 1.5 miles north of Muncie
2N	1.0	1.5 to 2.5 miles north of Muncie

Table 1A (continued)

Subsection	Length-Miles	Description
3N	1.0	2.5 to 3.5 miles north of Muncie
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "
6N	1.0	5.5 to 6.5 " " " "
7N	1.0	6.5 to 7.5 " " " "
8N	1.0	7.5 to 8.5 " " " "
9N	1.5	8.5 miles north of Muncie to west city limits of Albany
	20.7	

Note: South of Muncie means south of south city limits.
North of Muncie means north of north city limits.

Section 9 - U.S. Highway 36 in Hendricks County

Subsection	Length-Miles	Description
0W	0.5	0.0 to 0.5 miles west of Danville
1W	1.0	0.5 to 1.5 " " " "
2W	1.0	1.5 to 2.5 " " " "
3W	1.0	2.5 to 3.5 " " " "
4W	1.0	3.5 to 4.5 " " " "
5W	1.0	4.5 to 5.5 " " " "
6W	1.0	5.5 to 6.5 " " " "
7W	1.7	6.5 miles west of Danville to Hendricks-Putnam County line
0E	0.5	0.0 to 0.5 miles east of Danville
1E	1.0	0.5 to 1.5 " " " "
2E	1.0	1.5 to 2.5 " " " "
3E	1.0	2.5 to 3.5 " " " "

Table 1A (continued)

Subsection	Length-Miles	Description
4E	1.0	3.5 to 4.5 miles east of Danville
5E	1.0	4.5 to 5.5 " " " "
6E	1.0	5.5 to 6.5 " " " "
7E	1.0	6.5 to 7.5 " " " "
8E	1.0	7.5 to 8.5 " " " "
9E	1.0	8.5 to 9.5 " " " "
10E	0.7	9.5 miles east of Danville to Hendricks-Marion County line
	18.4	

Note: West of Danville means west of west city limits.
East of Danville means east of east city limits.

Section 10 - State Road 67 in Morgan County

Subsection	Length-Miles	Description
0	1.0	0.5 miles south of Martinsville junction to 0.5 miles north of Martinsville junction
1S	1.0	0.5 to 1.5 miles south of Martinsville junction
2S	1.0	1.5 to 2.5 " " " "
3S	1.0	2.5 to 3.5 " " " "
4S	1.0	3.5 to 4.5 " " " "
5S	1.0	4.5 to 5.5 " " " "
6S	0.9	5.5 miles south of Martinsville junction to west city limits of Paragon
7S	0.5	East city limits of Paragon to 7.5 miles south of Martinsville junction
8S	1.0	7.5 to 8.5 miles south of Martinsville junction

Table 1A (continued)

Subsection	Length-Miles	Description
9S	1.0	8.5 to 9.5 miles south of Martinsville junction
10S	1.5	9.5 miles south of Martinsville junction to Morgan-Owen County line
1N	1.0	0.5 to 1.5 miles north of Martinsville junction
2N	1.0	1.5 to 2.5 " " " "
3N	1.0	2.5 to 3.5 " " " "
4N	1.0	3.5 to 4.5 " " " "
5N	1.0	4.5 to 5.5 " " " "
6N	1.0	5.5 to 6.5 " " " "
7N	1.0	6.5 to 7.5 " " " "
8N	1.0	7.5 to 8.5 " " " "
9N	1.0	8.5 to 9.5 " " " "
10N	1.0	9.5 to 10.5 " " " "
11N	1.0	10.5 to 11.5 " " " "
12N	1.0	11.5 to 12.5 miles north of Martinsville junction
13N	1.0	12.5 to 13.5 " " " "
14N	0.5	13.5 miles north of Martinsville junction to South city limits of Mooresville
16N	1.1	North city limits of Mooresville to Morgan-Johnson County line
	25.4	